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**ASSESSMENT OF EXISTING
OVERHEAD LINE
SUPPORTS**

**Working Group
B2.08**

June 2003



ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

Working Group

B2.08

June 2003

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CIGRE WG B2.08

OHL SUPPORTS

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

(Steel towers, guyed steel structures, steel, concrete and wood poles
for rated nominal voltage above 45 kV)

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Purpose of this Technical Brochure

This Technical Brochure on the Answers to the Questionnaire on the “Assessment of Existing Overhead Line Supports” will present the analysis of the different answers, comments and inspection procedures provided by the respondents. This document is an attempt to synthesize the items ranked according to their importance estimated by those respondents.

The General Paper hereafter is intended for the use of distribution and transmission support owners in order to take advantage of the worldwide experience in this field.

The Electra Paper (Electra No. 207, April 2003, pp.18 – 26) summarizes the most remarkable conclusions of the questionnaire analysis.

Thanksgiving

We would like to thank all participants worldwide for the time spent answering the questionnaire on the assessment of overhead line supports, which was understood to be comprehensive. We also thank for their comments, age distribution graphs, extracts from their inspection sheets, procedures and any kind of information they provided to make a success of this overview of the progress in the assessment of overhead line supports.

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Review of this Technical Brochure

Finally, we thank the SC B2 reviewers Faure Hubert (France) and Riisiö Pekka J. (Finland) for their useful comments and proposals.

It was the reviewer's suggestion (Riisiö Pekka J.) "to take advantage of the great work made for this report, that this questionnaire should be repeated in the future partly with the same questions and partly with modified and new questions. Then we could try also to get the coverage in the different countries answering the questions larger and more representative also among the developing countries. The work would be much easier, because the basic work (forms of questions, result tables, compilation policy, etc) is already done".

CIGRE WG B2.08

OHL SUPPORTS

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

**(Steel towers, guyed structures, steel, concrete and wood poles
for rated nominal voltage above 45 kV)**

ELECTRA PAPER

June, 2003

(Electra No. 207, April 2003, pp. 18 – 26)

Electra paper

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

Task Force B2.08.01 on behalf of Working Group B2.08 “Overhead Line Supports”

Summary

Some time ago, TF B2.08.01 prepared and sent abroad a comprehensive questionnaire of 37 pages and 316 questions. The aim was to collect and to compare worldwide information about practices on assessment of all types of existing overhead line supports. The reply was very successful. All items have been ranked according to their importance estimated by the 61 respondents. The Electra report summarizes some remarkable results from the Technical Brochure such as inspection techniques, causes and types of defects and management criteria to undertake actions, especially routine maintenance, repair, life extension, refurbishment and upgrading of supports.

Résumé

Dans le passé, le Groupe d'Action B2.08.01 a préparé un questionnaire de 37 pages, qui a été largement diffusé. L'objectif était de rassembler et de comparer l'information mondiale concernant les pratiques dans l'évaluation de tous types de supports de lignes aériennes existantes. La réaction aux 316 questions était un succès. Tous les items ont été classés suivant leur importance estimée par les 61 correspondants. Le rapport Electra résume quelques résultats remarquables de la Brochure Technique, comme les inspections techniques, les causes et types de défauts et les critères managériaux pour entreprendre des actions, spécialement la maintenance, la réparation, l'extension de la durée de vie, la rénovation et le renforcement des supports.

1. Scope

The aim of the Technical Brochure “ Assessment of Existing Overhead Line Supports ” was to collect and to compare worldwide information about practises and experiences on inspection methods, diagnostic tools, defects and assessment of existing overhead line (OHL) supports in order to undertake works and actions such as routine maintenance, repair, life extension, refurbishment and finally upgrading of supports.

The OHL supports considered include :

- self supporting lattice steel structures (towers);
- guyed lattice steel structures;
- self supporting hollow steel section structures;
- steel poles;
- concrete poles (pre-stressed or reinforced);
- wood poles.

In order to receive representative information, Task Force 01 of Working Group B2.08 “Overhead Line Supports” prepared a comprehensive questionnaire of 37 pages that was sent abroad. The reply was very successful. A total number of 61 filled-in questionnaires from 30 different countries have been registered. All answers were separated into two nominal voltage ranges : respectively 45 kV up to 150 kV and/or above 150 kV. It took a long time to collect, to verify, to categorise and to arrange all data and comments received. The answers vary largely with the respondent. The results of this work have been compiled in the Technical Brochure and are summarised hereunder.

2. Questionnaire

2.1. Chapters

The questionnaire included the following ten chapters :

1. Introduction;
2. General information on the existing supports;
3. Criteria for management of supports;
4. Inspection philosophies;
5. Type and causes of defects;
6. Inspection tools and methods;
7. Inspection reports;
8. Assessment of inspection data;
9. Experiences and solutions;
10. Suggestions for future CIGRE work.

The Technical Brochure on the Assessment of Existing Overhead Line Supports will present the analysis of the different answers, comments and inspection procedures provided by the respondents to the different chapters of the Questionnaire. All items mentioned in the Questionnaire sent abroad have been ranked according to their importance estimated by those respondents.

The General Report of the Technical Brochure is intended for the use of distribution and transmission support owners in order to take advantage of the worldwide experience in this field.

2.2. Responses to the questionnaire

The following 30 countries responded to the questionnaire:

- Africa : South Africa, Zambia, Zimbabwe;
- Asia : Bangladesh, Japan;
- Europe : Austria, Belgium, Denmark, Finland, France, Germany, Great Britain, Italy, Iceland, Ireland, Netherlands, Norway, Portugal, Romania, Slovenia, Spain, Switzerland, Turkey;
- North America : Canada, USA;
- Oceania : Australia, New Zealand;
- South America : Argentina, Brazil, Venezuela.

Each respondent has been considered as an expert and consequently as a unique entity, irrespective of the number of responses from the corresponding country and of the scale of this country.

2.3. Different kinds of answers

In the questionnaire 5 kinds of answers for each item mentioned were possible :

- yes or no (or not applicable, or not available);
- a priority level ranging from 1 (most frequent or very important) to 5 (very seldom or less important);
- a numerical value (such as a period between successive inspections or a sample size);
- comments on the item mentioned;
- enclosures such as :
 - distribution graphs of OHL support ages,
 - inspection procedures and forms for OHL supports,
 - information on actions such as painting and upgrading of OHL supports.

The Technical Brochure on the Assessment of Existing OHL Supports does not intend to evaluate the accuracy of each answer but to arrange the information collected worldwide :

- according to the importance estimated by the respondents as a whole;
- according to the importance estimated by any respondent as an individual expert.

2.4. Ranking of the items

For the first kind of answer, all items have been ranked according to the absolute number of answers “yes”, irrespective of the number of answers “not applicable” or “not available”.

For the second kind of answer (priority level 1 to 5) two ranking systems have been applied :

- the first system (score 2) is very simple and based only on the number of the highest level 1. This ranking system allows to detect the most important issues for a limited number of countries (and not necessarily for all countries) : those issues are generally very typical for the local environment, climate or type of support;
- the other system (score 1) is the most significant one and is based on a weighted mean of the number of all priority levels in order to find the common issues most spread all over the world and generally known by any country.

3. Content of the Technical Brochure

The “General Report” of the Technical Brochure “Assessment of Existing Overhead Line Supports” includes the synthesis of all answers provided.

Appendix A includes a copy revised of the questionnaire sent abroad in July 1998.

Appendix B includes all the detailed comments made by the respondents. Enclosures B1 to B3 include comments on the age profile of OHL supports, on inspection procedures and on upgrading or refurbishment actions.

Appendix C includes the detailed statistical summary of the answers to the questionnaire and the ranking of the items as well. Enclosures C1 to C3 include the statistical summary of the answers relating to special supports such as guyed structures, concrete poles and wood poles.

4. Some extracts of the General Report

4.1. Management decisions on actions

4.1.1. Criteria for management decisions

The **probability of collapse** of the support or its **unreliability** is considered by a majority of 41 respondents (on a total of 90 responses) by far as the most important criterium for management decisions. This statistical result confirms the appropriate approach proposed by WG B2.13 "Management on Existing Overhead Lines" where the quantitative criterium for the selection of the appropriate management action is based on minimising the total sum of expenditures and risks, where risk is defined as the multiplication of the **failure probability** (unreliability) and the **consequences** expressed in monetary terms (see CIGRE Technical Brochure n° 175).

The **analysis of the deterioration process** is considered as a secondary criterium. This analysis includes the detection of the defect by its **symptom**, the determination of the type of defect, the measurement or the evaluation of the present degree of this defect and possibly its progress rate, the estimation of the **source and/or the cause** as a function of the local environment and finally the estimation of consequences (Fig. 1).

It is understandable that the probability of collapse is a more significant criterium and a major concern for most companies. It depends on the ratio of the residual strength to the actual loading. However, the type, source and symptom of defect on the contrary does not reflect the loading, but only the residual strength.

The **network performance** or its availability and the **available budget** are still minor criteria but can become more relevant in the environment of the electricity market deregulation and the competition of the utilities due to the opening of transmission networks.

The ranking of the criteria for management decisions on supports according to the weighted mean in % (score 1) as well as to the number of priority levels 1 (score 2) is mentioned in Table 1. We note that the **deterioration of the condition** of the existing supports with reference to the **original condition** (strength) (item 5) seems to be a very important issue for a few individual companies but less for the companies as a whole because score 2 is relatively higher.

Table 1 – Criteria for management décisions on actions			
Ranked items		Score 1	Score 2
1.	probability of collapse (unreliability)	47 %	41
2.	symptoms of defects	39 %	19
3.	sources of defects	35 %	13
4.	Network performance (availability)	30 %	11
5.	Existing condition / original strength	27 %	16
6.	available budget	21 %	7

4.1.2. Actions on supports

The process of the management decisions on actions is summarised in Fig.1.

- **Maintenance by occasional local repair** is performed by nearly all the respondents to the questionnaire. Nevertheless **maintenance by routine conservation** is not done by 14 % of the respondents. The **removal of the vegetation** under the support is the main reason for support maintenance followed by **minor corrosion**.
- **Life extension** (improving residual strength without restoring initial strength) and in a minor degree **refurbishment** (restoring design strength) is done by a great majority of respondents probably not systematically but rather after an element failure. **Extensive corrosion due to either normal weathering or industrial pollution** is by far the most important reason for life extension and/or refurbishment, much more than **local deformation** of elements, cross-arms and support shaft.

A typical difference between life extension and refurbishment is given by the following example :

- if the strength of the steel angle remains sufficient despite corrosion, its life can be extended by painting;
- if corrosion damage is too great, the steel angle can be refurbished by replacing.
- **Upgrading** (increasing original strength) is as popular as life extension, but generally needed in the context of the overhead line uprating (improving the electrical characteristics of the line such as the transport capacity). In the case of uprating, upgrading can be avoided by real time monitoring methods to determine the real static (or dynamic) thermal rating without exceeding the limit temperature in the conductor.

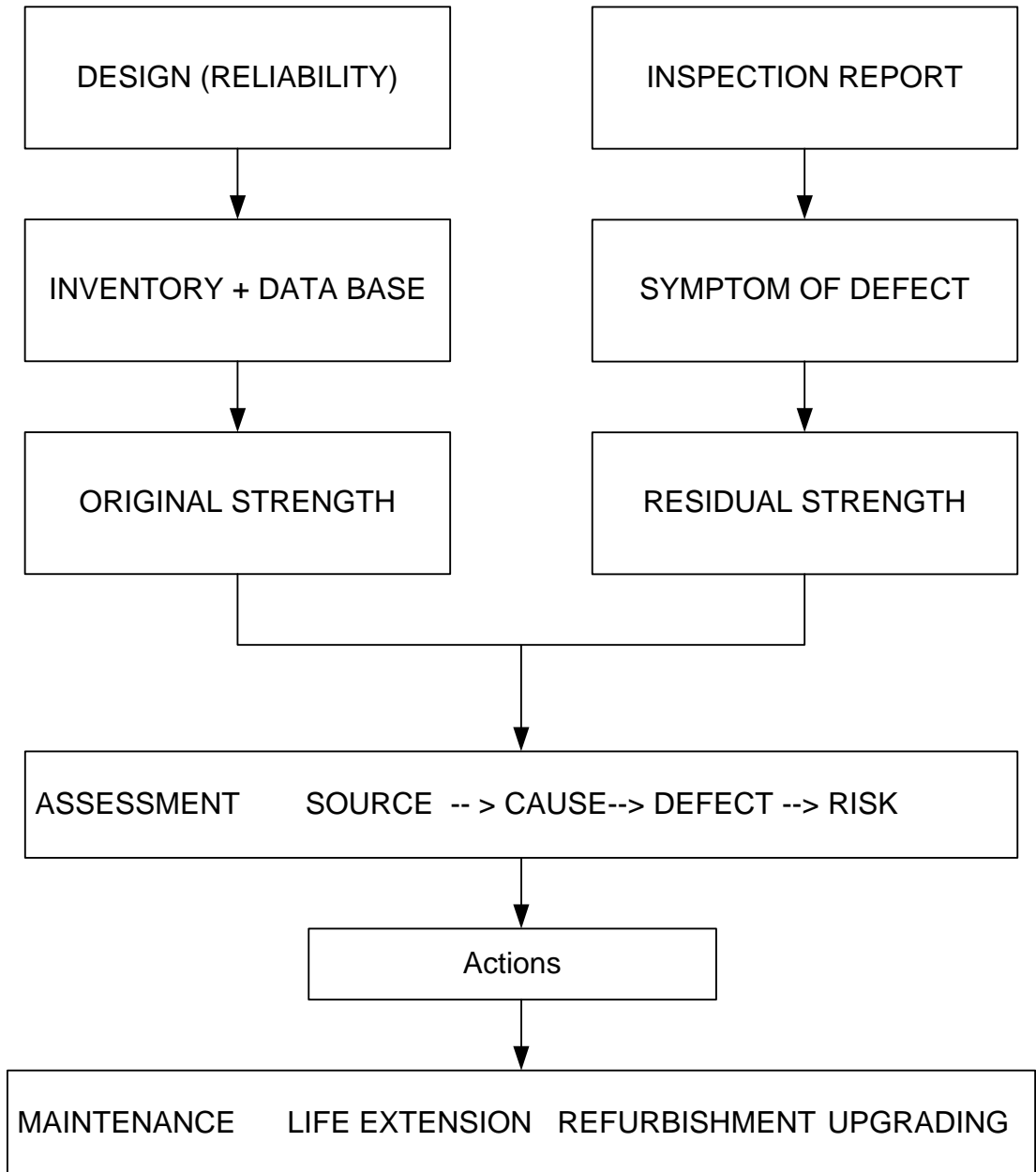


Fig. 1 BASE OF MANAGEMENT DECISIONS ON SUPPORTS

On the contrary, **uprating** of the overhead line, especially by either **higher ground clearances** or **larger conductor size**, **higher operation temperatures**, **higher voltage level**, etc., is the major reason for upgrading. Reasons for upgrading are ranked in Table 2. The ranking according to score 2 is different from score 1.

Ranked items		Score 1	Score 2
1	higher ground clearance	35 %	20
2	higher transport capacity by conductor change	28 %	14
3	higher operation temperature	24 %	15
4	installation of OPGW, antenna, ...	17,1 %	7
5	higher voltage level	16,6 %	11
6	higher meteorological loads	15 %	9
7	larger internal electrical clearances	9 %	3
8	electromagnetic impact demands	6 %	2

4.2. Inspection philosophies

Each company performs a regular inspection on supports.

Inspection methods are currently reviewed. Generally, the inspection level is a function of identified risk, whether structural, by vegetation or by encroachment.

Inspection **from helicopter** is now becoming the most common method (± 74 %) used for lines above 150 kV, while for lines from 45 kV up to 150 kV this method is still not used so much (± 59 %) as by **climbing** (63 %). Inspection **from car** (or on foot if the structure is not easily accessible) is becoming less popular.

Visual inspection **from ground** is considered as the most usual method (74 %), but for OHL above 150 kV it is still used as much as from helicopter (respectively 75% and 74%).

Inspection Type	Period (year)		Sample (%)	
	Median	Mean	Median	Mean
Car	1,0	1,4	49	57
Ground	1,0	1,4	100	87
Climbing	2,8	4,2	33	53
Helicopter	1,0	1,5	100	94

4.3. Type and causes of defects

The most typical defects in supports are related to **corrosion** and **painting** problems. **Loose or missing bolts** as well as **deformation of support elements** are other typical types of defects. For many companies the corrosion problem at or below the ground level, where steel is in contact with the soil, is an important matter of concern. The connection of the main member to the foundation has to be protected.

Wind loading remains by far the most important cause of collapse of supports. It is followed by **combined wind and ice loading** and **ice loading** only. This has already been confirmed in earlier SC B2 questionnaires (CIGRE TB no. 109). **Material defect** is also a cause of collapse.

Corrosion caused by **normal weathering** is more frequent than by **industrial pollution**. **Salt corrosion** and **heavy vegetation growth** are circumstances favouring the corrosion process. The reasons for corrosion problems are various and none of them is preponderant except **no galvanising** and **no-repainting**. **Low or delayed maintenance** are also recorded as possible causes.

4.4. Inspection tools and methods

Inspection is currently limited to **visual inspection**. Destructive tests are seldom used on existing supports. Nevertheless more than half of the companies use EM **gauges** for measuring galvanisation and /or paint thickness on steel supports.

The residual tension in the **stays** of guyed supports is generally checked by dynamometers or clamps.

Some companies verify the global deformation and the resulting **geometry** of the steel supports.

4.5. Inspection reports

74 % of the companies use **formatted checklists** for support inspection. Generally these checklists are very specific and confidential. The electronic field books are up to now not so popular (only 16 %). Some companies record the inspection data in a special **Data Base** for statistical evaluation. Many companies (70 %) **categorise the urgency of repairs**, mostly according to two or three (or even four) different levels.

Many companies (75 %) differentiate the **corrosion** attack according to the **surface extent**, the **location** and the **depth**. Some give maximum values according to three categories of corrosion surface extent. The corresponding mean values are very high : respectively 6 %, 20 % and 58 %, compared to the initial values of the questionnaire (3 %, 10 % and - %). Some companies mentioned they do not have any corrosion problem.

4.6. Assessment of inspection data

In each company support lists, site maps and longitudinal profiles are available.

Most of the companies (92%) also have **workshop drawings of the supports** with the geometry and data on steel angles and bolts. Those data are useful for static calculation or verification of existing supports for new loading trees. 60 % of the companies already started a partial or complete **computer data base** of their existing OHL documents. Many companies (39 %) have a computerised data base identifying support location (and sometimes conductor clearances) by a GIS (Geographical Information System).

4.7. Experiences and solutions

This chapter refers to the particular experiences and solutions with repair and refurbishment of supports.

There are **a lot of precautions against vandalism and/or terrorism** (fencing, anchor bolts covered in concrete, securing tower bolts, protecting corner leg with concrete, special bolts, polymeric insulators, anti-climbing devices, isolation of the place).

Paragraph 9.2. in the Technical Brochure summarises the answers on the **type of paintings** used for steel structures on **black steel** as well as on **galvanised steel**. There is much variation in the type of paint coating as well as in the number of coats applied.

The **expected lifetime of coating** is 19 years (mean and median value).

5. Suggestions for future CIGRE work in WG B2.08

The areas to investigate in the context of CIGRE are ranked according to the preference of the responders :

1. Improvement of tools and methods for inspection (35 %) (23 levels 1);
2. Improvement of tools and methods for assessment (31 %) (17 levels 1);
3. Maintenance / upgrading friendly supports (23 %) (13 levels 1);
4. Determination / measuring of actual support strength (19 %) (10 levels 1);
5. Design improvement on footing area (19 %) (10 levels 1).

Working Group B2.08 “Overhead Line Supports” will try at least in the future to investigate and to improve tools and methods for inspection and assessment of supports and to follow up the items of increased interest.

CIGRE WG B2.08

OHL SUPPORTS

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

**(Steel towers, guyed structures, steel, concrete and wood poles
for rated nominal voltage above 45 kV)**

GENERAL REPORT

June, 2003

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1. Introduction

1.1. Purposes of the questionnaire

In July 1998, a questionnaire 22-98(WG 08)10 "Assessment of Existing Overhead Line Supports" of June 1998, established by the WG B2.08/TF01 (Convenor Prof. Dr. Ing. R. Paschen), was launched by the Convenor of the WG 08, Mr. João Batista Guimarães Ferreira da Silva among the CIGRE SC B2 Members and Observers. Its objective was to collect information around the world about practices and experiences in the field of :

- inspection philosophies;
- diagnostic tools;
- assessment of data on defects and failures;
- management decisions on maintenance, life extension, refurbishment and upgrading;
- ideas for future development,

especially for **existing overhead line (OHL) supports**, including :

- self supporting lattice steel structures (towers);
- guyed lattice steel structures;
- self supporting hollow steel section structures;
- steel poles;
- concrete poles (pre-stressed or reinforced);
- wood poles.

This questionnaire covered two following ranges of the voltage level :

- supports of **overhead "transmission" lines (OHTL)** > 150 kV;
- supports of **overhead "distribution" lines (OHDL)** ≤ 150 kV (and > 45 kV).

The definitions of transmission and distribution lines have been adopted especially for this questionnaire (see also list of definitions in § 1.5.).

The complete questionnaire sent abroad has been repeated in appendix A but some titles have been reviewed a little.

The questionnaire included the following ten chapters :

1. Introduction;
2. General information on the existing supports;
3. Criteria for management of supports;

4. Inspection philosophies;
5. Type and causes of defects;
6. Inspection tools and methods;
7. Inspection reports;
8. Assessment of inspection data;
9. Experiences and solutions;
10. Suggestions for future CIGRE work.

An overhead line (OHL) can be considered as an integrated system consisted of four components :

- supports;
- foundations;
- conductors;
- hardware and insulators.

However, some utilities are used to separate hardware and insulators.

Combined with data for the other line components (foundations, conductors, insulators and hardware), the data for supports can lead to a comprehensive overview for complete OHLs. WG B2.13 "Management of existing overhead lines" was already involved in this latter task in order to provide guidelines for management decisions on maintenance, refurbishment and, if appropriate, upgrading and uprating of the existing overhead lines (see Cigre Technical Brochure no. 175). Definitions and more details were already given in clause 1 of the above mentioned survey 22-98(WG08)10 of July 1998 and are repeated hereunder in 1.5.

This Technical Brochure on the Assessment of Existing Overhead Line Supports will present the analysis of the different answers, comments and inspection procedures provided by the respondents to the Questionnaire.

This document is an attempt to synthesize the items ranked according to their importance estimated by those respondents.

The General Report of this Technical Brochure is intended for the use of distribution and transmission support owners in order to take advantage of the worldwide experience in this field.

1.2. Replies to the questionnaire

The reception time for responses to the above mentioned questionnaire 22-98(WG08)10 has been closed before end 2000.

A total number of 61 filled-in questionnaires from 29 different countries have been received. The correspondence between the number (in appendix C) and the respondent has been considered as confidential.

Some of the answers cover the entire country in question while others only cover part of the country. The following countries have replied. The number between brackets after the name of the country corresponds to the number of answers for that country.

- Africa :
 - South Africa (1)
 - Zambia (1)
 - Zimbabwe (1)

- Asia :
 - Bangladesh (1)
 - Japan (1)

- Europe :
 - Austria (2)
 - Belgium (1)
 - Denmark (1)
 - Finland (1)
 - France (1)
 - Germany (8)
 - Great Britain (2)
 - Italy (1)
 - Iceland (1)
 - Ireland (1)
 - Netherlands (1)
 - Norway (2)
 - Portugal (3)
 - Romania (1)
 - Slovenia (1)
 - Spain (2)
 - Switzerland (4)
 - Turkey (1)

- North America :
 - Canada (3)
 - USA (5)

- Oceania :
 - Australia (6)
 - New Zealand (1)

- South America :
 - Argentina (1)
 - Brazil (5)
 - Venezuela (1)

Each respondent has been considered as an expert and consequently as a unique entity, irrespective of the number of responses from the corresponding country and of the scale of this country.

Moreover responses for overhead transmission and distribution supports have been analysed separately. We received :

- 43 responses for both OHTL and OHDL;
 - 10 responses for OHTL only;
 - 8 responses for OHDL only,
- i.e. 61 responses in total.

The number of responses analysed is 104 spread over :

- 53 (= 43 + 10) responses for OHTL;
- 51 (= 43 + 8) responses for OHDL.

1.3. Different kinds of answers

The replies to the questions have been collected, verified, categorised and arranged per sub-clause in order to make an analysis of the answers possible.

In the questionnaire in Appendix A there are 5 kinds of possible answers for **each item** in **each sub-clause** :

- yes (Y) or no (N).

A stripe (–) means that no definite answer has been given for the item considered. In this case, the answer was not available (or forgotten, not understood, not relevant, etc), but sometimes it was mentioned that the item was not applicable.

We did not make any difference between not available (NA) and not applicable (NA), because this information on the difference was not always available;

- an hit list of importance or a priority list. The priority level (further on simply called : level) range from 1 (most frequent or very important) to 5 (very seldom or less important). An item only highlighted or mentioned, but without any priority level between 1 and 5, was characterised by a cross : x; a stripe – means that no definite answer has been given for the item considered; once time again it could be an item that was either not available or not applicable;
- a numerical value such as :
 - a period expressed in years (for instance between inspections);
 - a sample size expressed in %;
- comments on the item (characterised by c);
- enclosures such as :

- distribution graphs of support ages;
- inspection procedures and forms;
- information on actions such as painting and upgrading.

The statistical results per respondent are summarised in Appendix C. However, her comments have been arranged in Appendix B.

Most of the enclosures are confidential and are not discussed in detail but only summarised in the enclosures B1 to B3.

This Technical Brochure on the assessment of existing OHL supports does not intend to evaluate the accuracy of each answer but to arrange the information collected worldwide :

- according to the importance estimated by the respondents as a whole;
- according to the importance estimated by any respondent as an individual expert.

1.4. Ranking of the answers available

For the first (Yes/Not) and second type (level 1 to 5) of answer, the **items in each sub-clause are ranked** according to their importance estimated by the respondents as a whole and/or as an individual.

1.4.1. Answers Yes/No (Y/N)

For the answers (Y/N) the **items** in this General Report are **arranged** according to the **rising** total number of yes (Y). If the number of Y is the same for 2 items, the items are ranked according to with the *falling* total number of no (N).

In Appendix C we provide two other ranking systems R_a and R_b according to the score S_a and S_b where :

- $S_a = N_y/N_o$;
- $S_b = N_y/(N_y + N_n)$;

and

- N_y = number of answer "yes";
- N_n = number of answer "no";
- N_- = number of answers with neither "yes" nor "no";
- N_o = total number of respondents to the questionnaire (yes, no, -);
- $N_o = N_y + N_n + N_-$.

The value of N_o is :

- $N_o = 104$ for OHL (for both OHTL and OHDL);

- $N_o = 53$ for OHTL;
- $N_o = 51$ for OHDL.

So, the **score** S_a is the relative value of the number N_y of "yes" corresponding to the total number N_o of respondents. The relative value of S_a gives the same ranking as the absolute value of N_y .

The ranking system R_b for **score** S_b does not take into account the answers with neither "yes" nor "no" (N-). This score is the relative value of the number N_y of "yes" corresponding to the total number of answers given ($N_y + N_n$). So both scores S_a and S_b are different : $S_a < S_b$. However the tables in Appendix C show that both corresponding ranking systems R_a and R_b almost give the same result, so that ranking system R_b was not an alternative for this General Report.

For the sake of simplicity, all items in this General Report are ranked according to the **absolute number of answers Y** irrespective of the number of "no applicable" or "not available".

To clear up the total number of answers of "yes" and "no", their figures N_y and N_n are also mentioned after the symbol "Y/N". The percentages also refer to the total number of respondents (N_o). The value expressed in percentage equals $100 S_a$.

1.4.2. **Answers 1 to 5**

For the answers 1 to 5 we have compared 3 ranking systems which arrange the items of each sub-clause.

The **first ranking system** R_1 according to the score S_1 is very simple and based only on the number of the highest level 1 (most frequent or very important) where :

$$S_1 = N_1$$

and :

$$N_1 = \text{number of level 1.}$$

This score does not take into account the other levels from 2 to 5. So, this ranking system allows to **detect the most important issues for only a limited number of utilities/countries**. If the total number of level 1 is the same for 2 or more items, the number of level 2 is determining, etc.

However, it has been established that the statistical distribution function of the number of level 1 per respondent is not normal (not gaussian). Moreover, a lot of respondents did **not** use at all the level 1 and their number was different according to the chapter of the questionnaire :

- **11** (11 %) for chapter 3 that deals with management actions on supports;
- **31** (30 %) for chapter 5 that deals with defects on supports.

On the contrary, for some other respondents **many** items are of priority level 1 and in a different rate for chapter 3 and 5.

This can be confirmed by the following **table 1** :

Table 1 - Distribution of level 1 (very important) used per respondent																					
Chapter	Number of level 1 per answer																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
3	11	14	12	15	28	9	5	3	1	1	-	1	-	3	1	-	-	-	-	-	104
5	31	4	19	11	7	6	11	6	-	1	1	-	-	-	-	-	-	4	2	1	104
Example : in Table 1 we emphasize that for 28 respondents 4 items from chapter 3 are considered as very important and of priority level 1.																					

It seems that for the respondents the management actions on supports are more important than their defects.

Probably the experts are more open to communicate their management actions on supports (in chapter 3) than their most frequent defects (in chapter 5). Besides, a significant minority of respondents is not willing or afraid to inform about their most important defects on supports. If they are aware of, this analysis can only be beneficial for them.

We can already conclude that the answers vary largely with the respondent. So the need to have a large sample of respondents for detecting important issues was justified.

This first ranking system did not take into account all the respondents (respectively 11 to 31% for chapter 3 and 5). So the consideration of an other ranking system was necessary.

The *second ranking system* R_2 according to the score S_2 takes into account all the answers, but the levels are considered with a different weight factor :

- level 1 : 100 %;
- level 2 : 80 %;
- level 3 : 60 %;
- level 4 : 40 %;
- level 5 : 20 %;
- level - : 0 %;
- level x : 50 % (mean value of weight factors for levels between 1 and -).

In this ranking system score S_2 is given by the following weighted arithmetic mean value :

$$S_2 = \frac{100N_1 + 80N_2 + 60N_3 + 40N_4 + 20N_5 + 50N_x}{N_0}$$

where :

- N_i = number of levels i ($i = 1$ to 5 or x) per item;
- N_0 = total number of respondents to the questionnaire (1 to 5, x , -).

- $N_0 = N_1 + N_2 + N_3 + N_4 + N_5 + N_- + N_x$.

The value of S_2 can vary between 0 (if all the respondents give a level "-" to the corresponding item) and 100 % (if all the respondents give a level 1 to the corresponding item). This second ranking system allows to find the **common issues most spread over the world or for every utility/country**.

Some problems can score very high in the first ranking system and very low in the second one. In this case the problem is limited to very few countries (for instance with a very typical environment, climate or type of support, etc) , but can be a concern for those countries.

However, the second ranking system of the items shows a smaller variation in results than the first one. In this case the large extent of the sample of 61 respondents can be justified to obtain a significant ranking of items.

It has been established that the result of the second ranking system is largely influenced by level 5. It was found that level 5 was used twice (chapter 3) to three times (chapter 5) any of the other levels. The statistical distribution function of the levels is not normal as can be seen in the next **table 2**.

Table 2 - Distribution of levels in % of respondents								
<i>Priority level</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>x</i>	<i>-</i>	<i>Total</i>
Chapter 3	11,9	11,7	12,0	11,5	25,0	1,7	26,3	100
Chapter 5	6,1	4,6	7,3	9,4	24,6	2,5	45,5	100

The answers can vary with the type of question. A lot of questions have not been answered, because the issue is not important. Probably level 5 is comparable with the stripe – (that means : not available or not applicable).

The arithmetic mean values of the second ranking system are mentioned in Appendix C for information only.

So, finally we introduced a **third ranking system R_3** according to the score S_3 to avoid the disadvantages of the second ranking system R_2 and to take advantage of the first ranking system R_1 by assigning :

- a relatively larger weight to the levels such as 1 and 2;
- a relatively smaller weight to the levels such as 5 and 4.

The scores are now considered with the following weight factor nearly according to geometric series :

- level 1 : 100 %;
- level 2 : 50 %;
- level 3 : 25 %;

- level 4 : 10 %;
- level 5 : 5 %;
- level - : 0 %;
- level x : 25 % (as score 3).

This is the best compromise :

- all levels are taken into account;
- higher levels are now more influential.

In this ranking system, score S_3 is given by the following weighted arithmetic mean value :

$$S_3 = \frac{100N_1 + 50N_2 + 25N_3 + 10N_4 + 5N_5 + 25N_x}{N_0}$$

1.4.3. Conclusion

Ranking system R_1 allows to detect the most important problems for a limited number of countries. However R_3 allows to detect the most common problems worldwide.

1.4.4. Statistical results

Tables 3 to 10 in Appendix C give the total number of answers Y and N or the total number of answers for the levels 1 to 5 for each item. In the ranking columns R, the items are arranged according to their importance estimated by the respondent, using the classification system explained here above.

Some answers such as Y/N, 1 to 5 have been :

- corrected, if clearly in contradiction with other reliable answers;
- added, if clearly forgotten but consistent with other answers.

This General Report also mentions the :

- (arithmetic) mean value;
- median as well as the first and ninth decile ¹;

of the numerical values obtained for inspection periods and sample sizes.

For more information about this questionnaire, clause 1 of the questionnaire in Appendix A may be read in parallel.

¹ : note – the median is the middle value of a set of values arranged in order of magnitude. The deciles are values which divide the array of those values in ten equal parts. 10 % of the values of this array are smaller than first decile; 10 % are larger than the ninth decile. Note that the fifth decile is the median.

The statistical results for OHTL supports (> 150 kV) are also summarised in the Appendix C and compared with the results for OHDL (≤ 150 kV).

1.4.5. Examples

- Answers Y/N

If :

- 70 = number of answers "yes";
- 20 = number of answers "no",

we will provide the following information :

$$Y/N = 70/20$$

The percentage of "yes" answers for 104 respondents is then $(70/104) \times 100 = 67\%$.

In this case $104 - 70 - 20 =$

- 14 respondents did not answer (equivalent with "-").

- Answers 1 to 5

If the number of answers for priority level :

1 is 30; 2 is 40 ; 3 is 6; 4 is 0 ; 5 is 0; x is 2 and "-" is $104 - 30 - 40 - 6 - 2 = 26$, we will provide the following information :

$$S_1 = 30 \text{ priority levels 1.}$$

$$S_2 = (100.30 + 80.40 + 60.6 + 50.2) / 104 = 64\%$$

$$S_3 = (100.30 + 50.40 + 25.6 + 25.2) / 104 = 50\%$$

1.5. Definitions

The following definitions are useful for the understanding of the following chapters of this General Report and are in accordance with the definitions given in chapter 1 of the questionnaire in Appendix A. Those definitions refer in the context of the Technical Brochure only to supports :

- **Assessment** of supports The process of interpreting information produced from the inspection of supports and data on service experience etc. in order to produce an **assessment report**.

- **Assessment report** of supports

An assessment report can be used to :

 - estimate the present structural strength or condition of the supports and / or;
 - predict the residual life either at the original design loads or at higher loads resulting from **upgrading** or line **uprating**.
- **Distribution**

In this Technical Brochure deemed to be 45 kV up to ≤ 150 kV (nominal voltage).
- **Inspection** of supports

This is the total process of detecting, measuring or estimating those characteristics or symptoms that contribute to the physical condition of the support elements using either destructive or non-destructive methods to enable the production of an **inspection report**.
- **Inspection report** of supports

An inspection report is a summary of the data collected by the inspection. It forms a basis for the **assessment**.
- **Life extension** of supports (retrofit)

Extensive renovation of supports without restoring their original design strength.
- **Maintenance** of supports

Routine conservation and small/local repair.
- **Refurbishment** of supports

Extensive renovation or repair of supports to restore their intended design strength.
- **Support**

All types of supports or poles whether self-supporting, guyed or chainette structures, irrespective of type of material.
- **Transmission**

In this Technical Brochure deemed to be > 150 kV (nominal voltage).
- **Upgrading** of supports

Increasing the original strength of supports which may resist increased loads.
- **Uprating** of a line

Increasing the electrical characteristics of a line due to, for example a requirement for :

 - higher transport capacity;
 - larger electrical clearances.

Uprating of a line may require **upgrading** of supports.

1.6. Appendices to the General Report

This document includes the synthesis of the answers provided. It is issued as a "General Report ". It does not include the comments of the respondents, the data and the compilation results of the questionnaire.

Appendix A includes a copy revised of the questionnaire sent abroad.

Appendix B includes all the comments made by the respondents.

Appendix C includes the statistical summary of the answers to the questionnaire and the ranking of the items as well.

Enclosures B1 to B3 include comments on the age profile of OHL supports, inspection procedures and upgrading or refurbishment action.

Enclosures C1 to C3 include the statistical summary of the answers relating to special supports such as guyed structures, concrete poles and wood poles.

To facilitate the reading of the four documents, the table of contents of the General Report and the Appendices A to C are consistent with the table of content of the Questionnaire.

The 10 same chapters of the Questionnaire are used throughout the General Report and the three Appendices.

2. General information on the existing supports

2.1. Type of supports

Table 2.1. in Appendix C gives for each respondent the types of supports which he refers to in his questionnaire according to the voltage range :

- > 150 kV : further on called as transmission voltage (OHTL);
- ≤ 150 kV : further on called as distribution voltage (OHDL).

The two summary **tables 3** and **4** below compare for both voltage ranges the number of replies covering the different types of supports as well as a range of quantity of supports.

The first figure corresponds to the transmission supports (> 150 kV) and the second figure to the distribution supports (≤ 150 kV).

The third figure corresponds to the sum of transmission and distribution supports.

Table 3 – Number of replies per type of support						
	<i>Abs.</i>			<i>Rel. (%)</i>		
	OHTL	OHDL	Total	OHTL	OHDL	Total
Self supporting steel lattice structure (tower)	52	48	100	98	94	96
Guyed steel lattice structure	19	4	23	36	8	22
Self supporting hollow steel section structure	3	6	9	6	12	9
Steel pole	12	20	32	23	39	31
Concrete pole (prestressed)	2	9	11	38	18	11
Concrete pole (reinforced)	4	12	16	8	24	15
Wood pole	8	20	28	15	39	27
Total of respondents	53	51	104	100	100	100

The self supporting steel lattice structure or the tower is by far the most common support. Nearly all the questionnaires filled in refer to the tower.

Unfortunately we received a very small number of questionnaires referring for instance for the wood poles. This number was too small to obtain significant statistical results. However we analysed the answers on specific questions regarding wood poles limited to the owners of wood poles (see enclosure C3).

The synthesis of the results of wood poles is provided in 5.1., 6.2.3., 9.1.1. and 9.8.

We also synthesized the results of guyed structures in 5.1., 5.5., 6.2.1. and 9.1.1. and concrete poles in 5.1., 6.2.2. and 9.1.1.

Table 4 – Number of replies per range						
	<i>Abs.</i>			<i>Rel. (%)</i>		
	OHTL	OHDL	Total	OHTL	OHDL	Total
Less than 1 000 supports	4	5	9	8	10	9
Between 1 000 and 10 000 supports	27	24	51	51	47	49
More than 10 000 supports	22	22	44	41	43	42
Total of respondents	53	51	104	100	100	100

2.2. Quantity of supports

Table 2.2. in Appendix C gives more details about the number of supports (x means here : more than 0 supports but a more precise value is not known).

2.3. Distribution of support ages

Enclosure 1 of Appendix B summarises the comments on the distribution of support ages. The form of the information asked in the questionnaire was free in order to give the possibility to the respondents to provide the information readily available.

26 % responded by providing either :

- a distribution graph (number of supports or geographical lengths of lines) of support/line ages;
- a mean age;
- a maximum age.

In some countries, the first distribution supports were erected in the 1920's. The transmission supports are generally less old. In some companies the information from before 1950 is missing.

We also emphasize that in most developing countries the construction rate was lower during the period 1940-1950 and slowed down from nearly 1990.

3. Criteria for management of supports

3.1. Most important criteria for management decisions

The **probability of collapse** of the support or its **unreliability** is considered by a majority of 41 respondents (on a total of 90 respondents answering) by far as the most important criterium for management decisions. This statistical result confirms the appropriate approach proposed by WG B2.13 "Management on existing overhead lines" where the quantitative criterium for the selection of the appropriate management action is based on minimising the total sum of expenditures and risks, where risk is defined as the multiplication of the probability of **failure** (unreliability) and the **consequences** expressed in monetary terms (see CIGRE Technical Brochure n° 175).

The **analysis of the deterioration process** is considered as a secondary criterium. This process includes the detection of the **defects by its symptom** (for 19 respondents considered as the most important criterium), the determination of the type of defect, the measurement or the evaluation of the present degree of this defect and possibly its progress rate, the estimation of the **source and/or the cause** as a function of the local environment and finally the estimation of the consequences.

It is understandable that the probability of collapse is a more significant criterium and a major concern for most companies. It depends on the ratio of the residual strength to the actual loading. The type, source and symptom of defect on the contrary does not reflect the loading, but only the residual strength.

The degradation of the **condition** of the supports with reference to the **original condition** (strength) seems to be a very important issue for a few companies ($R_1 = 3$) but less for the companies as a whole ($R_3 = 5$) (see Table 3.2. in Appendix C)..

The **network performance** or its availability and the **available budget** are still minor criteria but can become more relevant in the environment of the electricity market deregulation and the competition of the utilities due to the opening of transmission networks.

The ranking is significantly the same for both voltage ranges (OHTL and OHDL).

According to the replies, the most important criteria for management decisions are ranked below.

Table 3.2 in chapter 3 of Appendix C gives more details on the mean weighted score S_3 in % and the total number S_1 of level 1. For the detailed meaning of the ranking systems we refer to 1.4.2.

Ranking according to system 3 (scores S_3 and S_1 are mentioned between brackets).

- 1 - probability of collapse (unreliability) (47 % - 41 times level 1);
- 2 - symptoms of defects (39 % - 19 times level 1);
- 3 - sources of defects (35 % - 13 times level 1);
- 4 - network performance (availability) (30 % - 11 times level 1);

- 5 - existing condition / original strength (27 % - 16 times level 1);
- 6 - available budget (21 % - 7 times level 1).

The ranking system 1 based on the highest level 1 gives here nearly the same results as the ranking system 3 based on the 5 levels except for item 5 (existing condition/original strength), but shows a much higher variability (7 to 41 times level 1 versus of 21% to 47%). For the comment of the CIGRE SC B2 reviewer, see §3.6.

3.2. Management decisions on supports

Maintenance by occasional local repair is performed by nearly all the respondents to the questionnaire. Nevertheless **maintenance by routine conservation** is not done by 14 % of the respondents (for the definitions see sub-clause 1.5.).

Life extension (improving residual strength without restoring initial strength) and in a minor degree **refurbishment** (restoring design strength) is done by a great majority of respondents probably not systematically but rather after an item failure.

Upgrading (increasing original strength) is as popular as life extension, but generally needed in the context of the overhead line uprating (increasing the electrical characteristics of a line).

In the case of uprating, upgrading can be avoided by real time monitoring methods to determine the real static (or dynamic) thermal rating without exceeding the limit temperature in the conductor. If uprating has been performed by either larger conductors or higher operating temperature, upgrading of the structures by heightening and/or strengthening may be necessary.

The management decisions are nearly the same independently of the voltage range (either OHTL or OHDL), except for the maintenance by routine conservation (+7 %), life extension (+8 %) and upgrading (+13 %) which are significantly more important for OHDL than for OHTL. Probably it is due to the fact that OHDL are older than OHTL.

Table 3.1 of chapter 3 of Appendix C gives more details on the number of answers "yes" and "no".

Ranking according to system Y/N (as explained in detail in 1.4.1.) :

- 1 - maintenance : occasional local repair Y/N = 94/2;
- 2 - maintenance : routine conservation Y/N = 88/14;
- 3 - life extension (improving residual strength) Y/N = 79/19;
- 4 - refurbishment (restoring design strength) Y/N = 77/18;
- 5 - upgrading (increasing original strength) Y/N = 69/29.

For definitions see sub-clause 1.5.

3.3. Reason for maintenance

The **removal of the vegetation** under the support is the main reason for support maintenance followed by **minor corrosion**.

Paint deterioration and/or **deformed elements** are of similar importance. Nevertheless paint deterioration and vegetation is a little more important issue for distribution supports (resp. $S_3 = 28\%$ and 49%) than for transmission supports (resp. $S_3 = 25\%$ and 45%) (see table 3.2. of Appendix C).

Loose bolts remain a minor reason for maintenance.

Ranking according to system 3 (see Table 3.2. in Appendix C) :

- | | | |
|-----|---------------------------------------|-----------------------|
| 1 - | vegetation in the area of the support | (47 % - 33 levels 1); |
| 2 - | minor corrosion | (36 % - 21 levels 1); |
| 3 - | paint deterioration | (27 % - 12 levels 1); |
| 4 - | deformed support elements | (26 % - 9 levels 1); |
| 5 - | loose bolts | (19 % - 6 levels 1). |

Many other reasons for maintenance not mentioned in the questionnaire have been noticed by the respondents in the comments (see Appendix B) as of priority level one: loss of galvanisation, crack corrosion, flooding, vandalism, corrosion at ground-air interface, ground line rot of wood pole, vandalism and theft, defective insulation, etc.

3.4. Reason for refurbishment / life extension

Extensive corrosion due to either normal weathering or industrial pollution is by far the most important reason for support refurbishment and/or life extension, much more than **local deformation** of elements, cross-arms and support shaft.

Nevertheless the **inclination of the support** and the **global deformation** is not considered as an important issue. Even the deformation of the support due to uneven settlements of the foundations (pad and chimney or pile) is not a major reason for refurbishment.

Some companies are concerned about the **corrosion problem on the interface steel/ground** for special structures (grillage foundations, guys, ...).

Damage by vandalism and terrorism is a huge problem for a few companies ($R_1 = 3$), but not at all for the other companies ($R_3 = 4$) (see Table 3.2. of Appendix C).

A typical difference between refurbishment and life extension is given by the following example :

- if the strength of the steel angle remains sufficient despite corrosion, its life can be extended by painting;
- if corrosion damage is too great, the steel angle can be refurbished by replacing or reinforcing.

In an other extreme scenario the supports are repainted when the residual lifetime of the paint is less than 2 years so that corrosion does not appear except in some cases.

Ranking according to system 3 (see Table 3.2. of Appendix C):

- | | |
|--|-----------------------|
| 1 - extensive corrosion : normal weathering | (38 % - 29 levels 1); |
| 2 - extensive corrosion : industrial pollution | (27 % - 16 levels 1); |
| 3 - connection to foundation (local corrosion) | (19 % - 9 levels 1); |
| 4 - deformation by vandalism | (16 % - 10 levels 1); |
| 5 - deformation of cross-arms | (16 % - 4 levels 1); |
| 6 - deformation of support shaft | (12 % - 4 levels 1); |
| 7 - support inclination | (12 % - 2 levels 1); |
| 8 - support deformation due to uneven foundation settlements | (10 % - 1 level 1); |
| 9 - global support deformation | (6 % - 2 levels 1). |

The respondents give a lot of other reasons for refurbishment (see comments in Appendix B).

3.5. Reason for upgrading

Upgrading of the overhead line (or increasing their electrical characteristics), especially due to **higher ground clearances** or **larger conductor size**, **higher operation temperatures**, **higher voltage level**, ..., is the major reason for upgrading (or increasing initial strength).

In some companies the supports have been upgraded due to the **installation of special equipments** such as the optical ground wire (OPGW), antenna, etc. but less for OHDL ($S_3 = 15\%$) than for OHTL ($S_3 = 19\%$) (see Table 3.2. of Appendix C).

Higher meteorological loads (wind, ice, wind and ice, ...) have been or will be considered due to more reliable statistical meteorological data or after recent heavy disastrous storms. This leads to the upgrading of strategic lines or supports.

Larger internal electrical clearances between phases, **electromagnetic impact demands**, etc. are very seldom reasons for upgrading.

The results are nearly the same for distribution and transmission lines, but it seems that upgrading, particularly by replacing the old (corroded ?) conductors by conductors with a higher transport capacity is more important for distribution lines ($S_3 = 33\%$) than for transmission lines ($S_3 = 23\%$). Higher ground clearance is also much more important for OHDL ($S_3 = 40\%$) than for OHTL ($S_3 = 31\%$).

Ranking according to system 3 (see Table 3.2. of Appendix C):

- | | |
|--|-----------------------|
| 1 - higher ground clearance | (35 % - 20 levels 1); |
| 2 - higher transport capacity : conductor change | (28 % - 14 levels 1); |

- 3 - higher operation temperature (24 % - 15 levels 1);
- 4 - installation of OPGW, antenna, ... (17,1 % - 7 levels 1);
- 5 - higher voltage level (16,6 % - 11 levels 1);
- 6 - higher meteorological loads (15 % - 9 levels 1);
- 7 - larger internal electrical clearances (9 % - 3 levels 1);
- 8 - electromagnetic impact demands (6 % - 2 levels 1).

Some other reasons for upgrading have been mentioned by the respondents (see Appendix B.3.5.) such as : change in soil/terrain conditions ; new wind code regulations, etc.

3.6. Comment from the reviewer

It can be noticed that the importance of uprating/upgrading of the supports and lines is still a growing subject worldwide. The results on the reasons for the decision-making and management of the lines were somehow surprising. The most important criteria was the collapse of the support and the second criteria was the deterioration of the material. The overall life cycle cost estimation was not considered as an important reason.

One of the reviewer's explanations may be the growing competition in the liberated electricity market. This may lead to short-term decisions and maximising the sales benefits within only a few years time. The ages of the electric companies are reducing due to possible changes in the ownership. Also the bankrupts are possible. This might tempt the companies to construct cheaper (more competitive ?) supports, which seem to satisfy the requirements of the design standards in the beginning, but at least due to the neglected or insufficient maintenance get damaged or deteriorated far before the end of their estimated life time. However, by that time the line owner or at least the contractor company has disappeared from the market and is not available to carry its responsibilities.

4. Inspection philosophies

4.1. Regular inspection

Each company performs a regular inspection on supports.

Inspection methods are currently reviewed. Generally, the inspection level is a function of identified risk, whether structural, vegetation or encroachment.

A major attention is paid to those links which show greater problems of interference with the surrounding environment.

Inspection **from helicopter** is now becoming the most common method (± 74 %) used for transmission lines, while for distribution lines this method is still used as much (± 59 %) as by climbing (63 %) (see Table 5 in 4.1.1.). Inspection **from car** (or on foot if the structure is not easily accessible) is becoming less popular (21 % for transmission lines and 25 % for distribution lines).

Visual inspection **from ground** is considered as the most used method (74 %), but for OHTL it is already used as much as from helicopter (respectively 75% and 74%).

The **sample size** (percentage of supports inspected) of inspection from helicopter and from ground is for more than the half of the companies both for transmission and distribution lines 100 % (median value) and only 49 % from car and 33 % by climbing. However for the strategic lines the last two values are much higher (respectively 65 % and 68 %) (see Table 7 in 4.1.1.).

The **mean period** between two successive inspections on transmission lines is nearly 1,5 year from helicopter and from ground and 4,2 years by climbing. The mean period of inspection is somewhat shorter for distribution lines than for transmission lines, except from car where the mean periods are the same (see Table 8 in 4.1.1.).

It is not at all clear why 15 companies declared not to inspect strategic lines while nearly all of them perform regular visual inspection on general lines. Probably they mean, such as the majority of the other respondents, that the inspection method, the period and the sample size is not different between general and strategic lines, or perhaps that they do not have any strategic lines !

The conclusion that the mean period is smaller for strategic lines than for general lines has also to be shaded, except by helicopter where the mean and median periods are the same. The smaller value is actually due to a few respondents giving no period for strategic lines.

Nearly 40 % of the respondents confirmed to inspect in a more detailed way by diagnostics, but according to the various comments, it seems that those diagnostics are almost not related to the supports but even more to the conductors, the insulators and the foundations.

However, inspection of painting, corrosion and loose bolts is mentioned.

Question : Do you inspect your supports regularly ?

Y/N = 104/0.

4.1.1. Regular visual inspection

Y/N = 100/4 : for general lines.

Y/N = 86/15 : for strategic lines.

Inspection from	Table 5 - Number of answers (%) on inspection for OHTL and OHDL					
	General line Number of answers for period					
	OHTL		OHDL		OHL	
Total	53	100%	51	100%	104	100%
Car	11	21%	13	25%	24	23%
Ground	40	75%	37	73%	77	74%
By climbing	33	62%	32	63%	65	63%
Helicopter	39	74%	30	59%	69	66%
Other	3	6%	2	4%	5	5%

Inspection from	Table 6 - Number of answers on inspection for OHL [total 104]			
	General Line		Strategic Line	
	<i>Period</i>	<i>Sample</i>	<i>Period</i>	<i>Sample</i>
Car	24	23	17	19
Ground	77	73	63	63
By climbing	65	63	53	53
Helicopter	69	65	60	58
Other	5	5	6	6

Example : 77 respondents (74%) mentioned the period between two consecutive inspections from ground but only 73 respondents gave the sample size (number of OHL supports inspected).

Table 7 - Periods/samples for OHL								
Inspection from	General line (OHL)				Strategic line (OHL)			
	Period (year)		Sample (%)		Period (year)		Sample (%)	
	<i>Median</i>	<i>Mean</i>	<i>Median</i>	<i>Mean</i>	<i>Median</i>	<i>Mean</i>	<i>Median</i>	<i>Mean</i>
Car	1,0	1,4	49	57	0,8	0,8	65	66
Ground	1,0	1,4	100	87	1,0	1,3	100	90
Climbing	2,8	4,2	33	53	1,0	3,0	68	60
Helicopter	1,0	1,5	100	94	1,0	1,5	100	95

Table 8 - Periods/samples for OHTL and OHDL								
Inspection from	General line (OHTL)				General line (OHDL)			
	Period (year)		Sample (%)		Period (year)		Sample (%)	
	<i>Median</i>	<i>Mean</i>	<i>Median</i>	<i>Mean</i>	<i>Median</i>	<i>Mean</i>	<i>Median</i>	<i>Mean</i>
Car	1,0	1,4	48	61	1,0	1,4	50	55
Ground	1,0	1,6	100	89	1,0	1,3	100	86
Climbing	3,0	4,5	40	53	2,5	4,0	25	54
Helicopter	1,0	1,7	100	93	1,0	1,3	100	94

4.1.2. Regular more detailed inspection

Y/N = 38/64 : by diagnostics

4.2. Only occasional inspection (after damage-event)

Seventeen companies answered they *only* do occasional inspection while each company declared to do regular inspection. It is possible that this question is ambiguous due to the simultaneous use of the wordings "only" and "(after damage-event)". Probably they also inspect after each damage event or after special meteorological circumstances.

Y/N = 17/81.

Other reasons for occasional inspection can be : after exceptional meteorological circumstances ; before upgrading.

4.3. Line Inspectors

Line inspectors have line experience (84 %) in the field, generally completed by a periodic practical or a specialised training. Sometimes they must have experience in erection of towers or they are former linesmen.

Specific training programs are foreseen in 47 % of the companies. Most of these training programs are confidential. Some items are refreshed. Some new skills are developed on the job. There are special safety procedures, tests and qualifications. Check of painting and wood pole rot requires skilled personnel.

4.3.1. Minimum requirements for line inspectors

Y/N = 87/17 : minimum requirements.

4.3.2. Training programme for line inspectors

Y/N = 49/55 : training programme.

4.4. Maintenance / refurbishment budget in % to overall budget OHL network ?

Half the companies have a maintenance and refurbishment budget of more than 15 % to 20 % to the overall budget expended on supports in the case of transmission lines. The mean budget (28 %) is the same for distribution and transmission lines. Only 67 % of the respondents replied to this question :

- number of answers : 70 (34 companies did not respond);
- median value : 17,5 % (OHTL : 15% - OHDL : 20%);
- mean value : 28 % (OHTL : 27% - OHDL : 28%).

4.5. Maintenance / refurbishment organised by own personnel ?

This is an important issue. All the companies responded. We received 104 answers.

In many companies (82 %) **maintenance** is completely (64%) or partially (18%) organised by own personnel. In 18 % of the companies the organisation of maintenance activities is partially contracted out.

The **refurbishment** activities are completely or partially organised by own personnel in 73 % of the companies.

Y/N = 66/19 and P/Y = 19/66 where P = partly yes for maintenance/refurbishment organised by own personnel.

Y/N = 66/19 for maintenance organisation by own personnel.

Y/N = 57/28 for refurbishment organisation by own personnel (according to the comments).

There is a tendency to outsource maintenance/refurbishment organisation.

4.6. **Maintenance / refurbishment activities performed by Contractors ?**

This is also an important question : all the companies responded to this question. We also received 104 answers.

In many companies **refurbishment** activities (71 %) and **maintenance** activities (58 %) are completely or partially contracted out.

In 28 % of the companies refurbishment and/or maintenance activities can be either contracted out or done by own personnel.

Y/N = 52/30 : from which P/Y = 22/52 where P = partly yes (some is done by own personnel).

Y/N = 52/30 : for refurbishment activities by own personnel.

Y/N= 38/44 : for maintenance activities by own personnel (according to the comments).

4.7. **Permanent condition monitoring**

Following the responses to the questionnaire 13 % of the companies have permanent condition monitoring, but such as in sub-clause 4.1.2. it does not probably refer to the supports but to the conductors. For instance real time monitoring for uprating (higher power transport capacity) is mentioned.

Anyhow, up to now only a small number of sensors have been installed in the network.

Y/N = 14/85.

5. Type and causes of defects

5.1. Typical identified faults

The most typical defects in supports are related to **corrosion** and **painting** problems. **Loose or missing bolts** as well as **deformation of support elements** are other typical types of defects. For many companies the corrosion problem at or below the ground level, where steel is in contact with the soil, is an important matter of concern. The connection of the main member to the foundation has to be protected (water proof).

Wood and concrete deterioration or decay are very important defects for distribution lines.

Many of these defects are of minor nature and do not need immediate attention. Critical defects are emphasised.

Reduced tension in stay wires or deformed stays are important defects for guyed supports.

Ranking according to system 3 (see Table 5.2. of Appendix C):

1.-	fault of structural steel corrosion	(31,2 % - 16 levels 1)
2.-	fault of protection painting	(30,9 % - 19 levels 1)
3.-	loose or missing bolts, nuts, washers	(19,8 % - 8 levels 1)
4.-	foundation connection	(13,8 % - 2 levels 1)
5.-	concrete deterioration	(13,5 % - 3 levels 1)
6.-	deformation of support elements	(12,8 % - 4 levels 1)
7.-	missing, deformed stays, guys, connections	(12,5 % - 4 levels 1)
8.-	deformation of crossarms	(10,4 % - 2 levels 1)
9.-	reduced tension in stay wires	(10,1 % - 5 levels 1)
10.-	wood deterioration	(9,9 % - 8 levels 1)
11.-	corrosion of small/thin members	(8,9 % - 2 levels 1)
12.-	defective welds	(5 % - 2 levels 1).

Half of the companies have more than 91 % (median value) of the supports without defects (95 % for transmission supports and 87 % for distribution supports) (see Table 5.2. of Appendix C).

If one limit the answers to the owners of specific supports we obtain higher scores for the following types of supports (see 2.1. and the tables in the enclosures to Appendix C) and sometimes an other ranking for OHL :

- Guyed structures
 1. reduced tension in stay wires (23 % > 10 %)
 2. missing, deformed stays, guys, connections (19 % > 13 %)
- Concrete poles
 1. concrete deterioration (20 % > 14 %)
- Wood poles
 1. wood deterioration (38 % > 10 %)

The second percentage between brackets corresponds to all the respondents as given above; the first percentage to the specific support.

5.2. Main cause of collapse of support (out of service)

Wind loading remains by far the most important cause of collapse of supports. It is followed by **combined wind and ice loading** and **ice loading** only. This has already been confirmed in earlier questionnaires. **Material defect** is also a cause of collapse.

Vandalism is considered as even important as ice loading. Wind loading is more important for transmission lines ($S = 30\%$) than for distribution lines ($S = 27\%$), but combined ice and wind loading is less important for transmission lines ($S = 16\%$) than for distribution lines ($S = 19\%$). **Public contact** or **motor vehicle accident** was forgotten in the questionnaire sent but mentioned by some respondents. **Cascade** is important but is generally not the main cause of the failure of a line.

Ranking according to system 3 :

1. - wind loading (29 % - 21 levels 1)
2. - wind and ice loading (17 % - 12 levels 1)
3. - vandalism (13 % - 6 levels 1)
4. - ice loading (12 % - 5 levels 1)
5. - cascade (11 % - 4 levels 1)
6. - material defect (11 % - 7 levels 1)
7. - erection / construction fault (8 % - 2 levels 1)
8. - conductor breakage (7 % - 2 levels 1)
9. - conductor vibration fatigue (6 % - 1 level 1)
10. - delayed preventive maintenance / refurbishment (6 % - 2 levels 1)



Many other causes of collapse of supports not mentioned in the questionnaire have been noticed by the respondents in the comments as of priority level one: motor vehicle collision ; incorrect maintenance practice ; landslide ; avalanches ; breaking down of foundations ; tornadoes, etc.

5.3. Type / cause of corrosion

Corrosion caused by **normal weathering** is more frequent than by **industrial pollution**.

Salt corrosion and **heavy vegetation growth** are circumstances favouring the corrosion process.

Ranking according to system 3 :

- | | | |
|----|--|----------------------|
| 1. | - Normal weathering | (47 % - 37 levels 1) |
| 2. | - Industrial pollution | (25 % - 10 levels 1) |
| 3. | - Salt corrosion (maritime site) | (18 % - 8 levels 1) |
| 4. | - Gap corrosion (resulting in pack rust) | (8 % - 3 levels 1) |
| 5. | - Heavy vegetation growth in temperate zones | (7 % - 4 levels 1) |
| 6. | - High humidity in temperate zones | (5 % - 2 levels 1) |
| 7. | - Inter crystalline corrosion of material | (5 % - 1 level 1) |
| 8. | - High humidity in tropical zones | (3 % - 0 level 1) |
| 9. | - Heavy vegetation growth in tropical zones | (3 % - 0 level 1) |

Many other types or causes of corrosion of supports not mentioned in the questionnaire have been noticed by the respondents in the comments as of priority level one: corrosion of steel in contact with the soil; corrosion of weathering steel, temporary accumulation of rain water, geothermal volcanic ash ; grillage footing below ground surface ; etc.

5.4. Reason of corrosion problem

The reasons for corrosion problems are various and none of them is preponderant except **no galvanising** and **no-repainting**. **Low or delayed maintenance** or **no-painting** are recorded as possible causes.

No-repainting problems are more important for distribution lines (S = 17 %) than for transmission lines (S = 11 %).

Ranking according to system 3 :

- | | | |
|----|-----------------------------|----------------------|
| 1. | - No galvanising | (15 % - 10 levels 1) |
| 2. | - No re-painting | (14 % - 6 levels 1) |
| 3. | - Low / delayed maintenance | (11 % - 4 levels 1) |
| 4. | - Weathering (Corten) steel | (10 % - 5 levels 1) |
| 5. | - No painting | (9 % - 1 level 1) |
| 6. | - Inadequate detailing | (5 % - 1 level 1) |

7. - Poor erection (4 % - 0 level 1)

Many other reasons of corrosion problems not mentioned in the questionnaire have been noticed by the respondents in the comments as of priority level one: buried steel; environment; inadequate painting; poorly performing paint system ; corrosion of galvanisation because of silicon-enriched steel, etc.

5.5. What is affected by the corrosion problem?

According to 19 companies, the **footing area** is the part of the support most affected by corrosion problems, particularly for transmission lines (OHTL : 30% - OHDL : 25%).

Shafts of **bolts**, washers and especially **nuts** are very corroded.

For the rest of the support, **secondary members**, main members and their connections (especially in transmission lines) are very affected by corrosion.

Other companies have very few corrosion problems. It would be interesting to localise geographically the most sensitive areas in the world.

Ranking according to system 3 :

- | | | |
|-----|--|----------------------|
| 1. | - Support footing area | (27 % - 19 levels 1) |
| 2. | - Nuts of bolts | (26 % - 15 levels 1) |
| 3. | - Secondary members of the steel lattice | (25 % - 17 levels 1) |
| 4. | - Complete support | (21 % - 14 levels 1) |
| 5. | - Main members of the steel lattice | (19 % - 9 levels 1) |
| 6. | - Shafts of bolts | (17 % - 8 levels 1) |
| 7. | - Washers of bolts | (17 % - 8 levels 1) |
| 8. | - Connections between bars | (16 % - 10 levels 1) |
| 9. | - Gusset plates (nodes) | (12 % - 4 levels 1) |
| 10. | - Sizes of the gusset plates | (11 % - 6 levels 1) |
| 11. | - Stays (cable) | (8 % - 3 levels 1) |
| 12. | - Stay connection (at ground / support) | (7 % - 2 levels 1) |
| 13. | - Welding seams | (6 % - 2 levels 1) |

If one limits the answers to the owners of guyed structures we obtain higher scores for (see 2.1. and the tables in the enclosure to Appendix C) :

- | | | |
|----|---------------------------------------|--------------|
| 1. | - Stay (cable) | (13 % > 8 %) |
| 2. | - Stay connection (at ground/support) | (11 % > 7 %) |

The second percentage between brackets corresponds to all the respondents as given above.

5.6. Type of deformation in the crossarm

Deformation of crossarms is considered as a minor problem. Rotation or torsion of the cross-arm around its longitudinal axis is more problematic than deformation of attachments points to the insulator sets, local deformation or cross-arm bending.

Ranking according to system 3:

- | | | | |
|----|---|---|---------------------|
| 1. | - | Rotation/torsion of the axis | (7 % - 4 levels 1) |
| 2. | - | Tip/attachment point for insulator sets | (7 % - 2 levels 1) |
| 3. | - | Local deformation | (6,0 % - 0 level 1) |
| 4. | - | Bending in the horizontal plane | (5,6 % - 1 level 1) |
| 5. | - | Bending in the vertical plane | (4 % - 0 level 1) |

5.7. Member of a crossarm broken by fatigue (due to areolian vibration of the member or conductor or both in resonance)

Y/N = 13/83.

Thirteen companies (12,5%) mentioned problems with the tension member (or other members) of the crossarm broken by fatigue probably due to areolian vibration of conductors.

Steel ductility problems are not reported, but local vibration cracks at bolt holes due to stress concentration are established.

To avoid resonance between conductor and member frequency, it is suggested to reduce the slenderness ratio of less than 300 in the upper girder of the crossarm.

6. Inspection tools and methods

Inspection is currently limited to **visual inspection**. Destructive tests are seldom used on existing supports.

Nevertheless more than half of the companies use EM **gauges** for measuring galvanisation and /or paint thickness on steel supports.

The residual tension in the **stays** of guyed supports is generally checked by dynamometers or clamps.

Detectors for the measurement of the **corrosion** of the support leg and the guys are also used.

Some companies verify the global deformation and the resulting **geometry** of the steel supports.

It seems that tests on wood and concrete poles are regularly performed. The extent of inspections on wood and concrete poles and guyed structures as well are reconsidered in the enclosures of Appendix C where the respondents will be limited to owners of this kind of supports. The present percentages now refer to all respondents with or without other supports than steel lattice structures.

Nearly 50 % of the companies performed **metallurgical, chemical and/or mechanical analysis** on support materials. This special laboratory examination is not systematically done, but rather rarely, mostly after failure. But a lot of companies mentioned that laboratory tests are useful only before manufacturing or erection, so that it is not clear if the rate of 50% only relates to existing structures or to both new and existing structures.

6.1. Methods used for inspection of supports

Y/N = 4/75 - Destructive inspection methods

Y/N = 89/8 - Non-destructive inspection methods

6.2. Special tools for inspection of supports

Y/N = 51/45

6.2.1. Steel supports

1. - Y/N = 52/32 - Galvanisation thickness meter (EM gauge)
2. - Y/N = 44/38 - Paint thickness meter (EM gauge)
3. - Y/N = 18/63 - Deflection/torsion of supports (e.g. with theodolite)
4. - Y/N = 17/53 - Stay tension measurement
5. - Y/N = 12/67 - Support leg corrosion detector
6. - Y/N = 9/71 - Steel corrosion metrology
7. - Y/N = 7/67 - Guy/Stay wire corrosion detector
8. - Y/N = 6/71 - Geometry (photogrammetry)

9. - Y/N = 2/66 - Endoscope device

Some other tools are mentioned such as copper sulphate half cell for grillage foundation.

If we limit the answers to the answers of guyed structures we obtain other ratios Y/N for (see 2.1. and the tables in the enclosure to Appendix C) :

1. - Guy/stay corrosion detector Y/N = 5/12
 2. - Stay tension measurement Y/N = 9/7

6.2.2. Concrete poles

- 1 - Y/N = 9/38 - Surface carbonation (chemical) (Y/N = 3/14)
 2 - Y/N = 8/40 - Deflection (Y/N = 6/11)
 3. - Y/N = 7/37 - Concrete impact device (Schmidt hammer)(Y/N = 2/12)
 4. - Y/N = 7/40 - Concrete quality detector (sclerometer) (Y/N = 3/14)
 5. - Y/N = 2/45 - Corrosion detector (Y/N = 0/16)

The values between brackets correspond to the number of owners of concrete poles (see enclosure 2 to Appendix C).

6.2.3. Wood poles

1. - Y/N = 21/18 - Drilled core (Y/N = 14/8)
 2. - Y/N = 18/21 - Hammer test (Y/N = 13/8)
 3 - Y/N = 7/33 - Decay drill (Shibert/Shannon) (Y/N = 6/13)
 4 - Y/N = 4/31 - Resistograph (Y/N = 6/15)

The values between brackets correspond to the number of owners of wood poles (see enclosure 3 to Appendix C).

The ultrasonic rot locators to check for decay have also been mentioned.

6.3. Special laboratory examination of materials

1. - Y/N = 49/43 - Chemical analysis
 2. - Y/N = 49/46 - Metallurgical analysis
 3. - Y/N = 39/52 - Steel properties (yield - impact)
 4. - Y/N = 35/53 - Electron - microscopic analysis

6.4. General comments on laboratory examinations

Advantage of analyses; when are they useful ? See comments in Appendix B.

Some advantages were mentioned many times such as :

- to establish the corrosion rate;
- in case of component failure,

to assess the reason of the failure :

- to get information on actual strength and remaining life;
- to assist in compiling condition-based maintenance programmes.

The interest to perform laboratory examinations during the manufacturing of elements and before the erection of the supports has been emphasised by many respondents.

7. Inspection reports

74 % of the companies use **formatted checklist** for support inspection. Generally these checklists are very specific and confidential. The electronic field books are up to now not so popular (only 16 %). Some companies record the inspection data in a special **Data Base** for statistical evaluation.

According to the respondents a lot of types of records are very important :

- first of all the **location** and the **number** of damaged steel angles are registered (69 %);
- secondly the **kind** of angle **deformation** is recorded : local deformation, bending, cracking, buckling or torsion in this sequence;
- another important data is the **degree of deformation**;
- the **global deformation** of the support shaft and top remains important but less than the local deformation;
- the **reduction of the cross-section** of the angles is still estimated by 34 % of the companies.

Many companies (75 %) differentiate the **corrosion** attack according to the **surface extent**, the **location** and the **depth**, but 32 % only give maximum values according to three categories of corrosion surface extent. The corresponding mean values are very high : respectively 6 %, 20 % and 58 % (and for the median values : 5 %, 18 % and 49 %), compared to the initial values of the questionnaire (3 %, 10 % and - %).

The variation of the maximum values is very high.

58 % of the companies categorise the **corrosion** according to the **depth**.

Some companies mentioned they do not have any corrosion problem.

Many companies (70 %) **categorise the urgency of repairs**, mostly in two or three (or even four) categories :

- (• no repair required);
- actions required but not with urgency;
- repair with urgency.

7.1. Use of checklist for support inspection

Y/N = 77/23 : checklist.

Y/N = 17/83 : electronic field book.

In the last case, the data are loaded in a hand held data recorder and afterwards downloaded to a PC.

7.2. Details of the records

See enclosure B2 of Appendix B.

7.3. Kind of records

1. - Y/N = 72/27 - Location of deformed/damaged steel angles
2. - Y/N = 70/29 - Number of deformed/damaged steel angles
3. - Y/N = 62/27 - Kind of angle deformation: local
4. - Y/N = 59/30 - Kind of angle deformation: bending
5. - Y/N = 56/29 - Kind of angle deformation: cracking
6. - Y/N = 53/35 - Kind of angle deformation: buckling
7. - Y/N = 47/46 - Degree of deformation
8. - Y/N = 44/51 - Displacement: support top
9. - Y/N = 41/41 - Kind of angle deformation: torsion
10. - Y/N = 35/60 - Reduction in cross-section
11. - Y/N = 33/60 - Global deformation (displacement of nodes)

Some other kinds of records have been noticed by the respondents in the comments : flange deformation ; presence, position and legibility of mandatory danger and number panels ; presence of warning panels with identification of circuits ; presence of anti-climbing guards ; deformation at base level due to animals and tractors ; reduction in cross-section of foundation stubs ; measurement of deformations if critical ; etc.

7.4. Differentiation of corrosion attack

1. Y/N = 78/20 - surface extent of corrosion attack
2. Y/N = 75/19 - location of corrosion attack
3. Y/N = 60/36- depth of corrosion attack

The depth of corrosion attack is a minor criterium because the thickness of galvanisation itself is variable.

Light or severe pitting is an other criterium, and "pack out" as well. Sometimes percentages are not put down, but comparison is made with standard photographs.

7.4.1. Categorising extent of corrosion surface

YN = 54/31

Table 9 - Corrosion attacks of surface				
Corrosion attack in % of surface	Y/N	Max. values given for attack degree		
		<i>Number</i>	<i>Median</i>	<i>Mean</i>
Low (e.g. 0 to 3 %)	45/28	33	5%	6%
Medium (e.g. 3 to 10 %)	42/28	32	18%	20%
High (e.g. above 10 %)	41/29	31	49%	58%

7.4.2. Categorising depth of corrosion attack

1. Y/N = 20/45 - Excessive surface oriented rust (say 90% profile thickness intact).
2. Y/N = 19/41 - Local rust attack with dents (say 70% profile thickness intact).
3. Y/N = 15/45 - Totally exposed hole in profile.

7.5. Categorising results of inspection activities identifying the urgency of repairs

Y/N = 73/25.

Generally the urgency of repairs are identified by minimum three and maximum four categories. At least the following three categories are mentioned :

- Good : no repair required;
- Not good : repair required without any urgency ;
- Critical : repair with urgency.

More categories can be foreseen either in order to differentiate the urgency or to foresee different repair delays.

8. Assessment of inspection data

In each company support lists, site maps and longitudinal profiles are available.

Most of the companies (92%) also have **workshop drawings of the supports** with the geometry and data on steel angles and bolts. Those data are useful for static calculation or verification of existing supports for new loading trees.

On the average 91 % of the transmission lines and 84 % of the distribution lines are covered by all documents. For respectively 8 % and 14 % of the information is not complete. In 1 % to 3 % of overhead lines no information is available, mostly of old lines. Some documents have been lost during world or independence wars. Profile maps are not always updated with new constructions built under or near existing lines.

Shop drawings of supports enable replacement of damaged members. Nearly each respondent has as-built support drawings (89%) and **reviews its shop drawing** (88%) after any modification on support. Otherwise the steel angles must be measured.

If the load carrying capacity of existing supports has to be verified, it is done in 84 % of the companies by **static calculation** and in 28 % of the companies by **tests**. This last figure is relatively high and probably also relates to new designs of new types of reinforcement.

60 % of the companies already started a partial or complete **computer data base** of the above mentioned documents. In 13 % of the companies all the information (100 %) has been recorded in the computer data base. On the average only 51 % (52 % for OHTL and 50 % for OHDL) of the data is recorded. In respectively 64% and 55% of the companies the support lists and longitudinal profiles are recorded digitally and regularly updated (respectively and 54% and 38%). In 42 % of the companies refurbishment / upgrading data are collected. **Historical data** are not always reliable but are recorded by 42 % of the companies.

Many companies (39 %) have a computerised data base identifying support location (and sometimes conductor clearances) by a GIS (Geographical Information System).

Assessment is done by **experienced technical personnel** on the basis of inspection report. In of the cases **defined parameters** of the component conditions are helpful for the management decisions.

In 86 % the **latest design standard** is used for upgrading, but in the case of **refurbishment** this decreases to 62 %.

In half of the cases the **design method is correlated by tests** on the entire support or individual elements. In 45% of the companies no test is done if all the calculation data are available.

61% of the responders are in favour of an **upgrading-friendly support**. The use of steel lattice towers is considered as user-friendly for upgrading and refurbishment. Many towers are initially used at a lower voltage level. Some tangent towers can be equipped with suspension or tension insulator sets.

Note : clause 8.1 and 8.2 refer to line documentation
 clause 8.3 and 8.4 refer to data handling
 clause 8.5 and 8.6 refer to assessment
 clause 8.7 to 8.8 refer to basic considerations

8.1. Available documents

8.1.1. Available line documentation

1. - Y/N = 101/1 - Support lists (Tower lists)
2. - Y/N = 97/5 - Site maps/longitudinal profiles
3. - Y/N = 96/6 - Workshop drawings of supports
4. - Y/N = 85/14 - Loading tree
5. - Y/N = 85/14 - Support geometry (*)
6. - Y/N = 77/20 - Steel profile and bolt data (*)
7. - Y/N = 74/23 - Steel quality data (*)
8. - Y/N = 34/20 - Concrete quality in case of concrete poles (*)

(*) : for static calculation of support

8.1.2. Comment if no documents

Sometimes considered as not necessary.

8.1.3. Part of network covered by documents

Respectively for OHL, OHTL and OHDL.

Table 10 - Network % covered by documents			
	<i>Number of values</i>	<i>Median %</i>	<i>Mean %</i>
All information	99 (51 + 48)	93 (95 – 90)	87 (91 – 84)
Some information	89 (46 + 43)	8 (5 - 10)	11 (8 – 14)
No information	86 (46 + 40)	0 (0 – 0)	2 (1 - 3)

8.1.4. Available documents on line modification

1. Y/N = 93/9 - As-built support drawings
2. Y/N = 92/4 - Modification support drawings

8.2. Load carrying capacity of existing supports

8.2.1. Verification if documents are available

1. Y/N = 86/7 - by calculation (P/Y = 1/86)
2. Y/N = 28/48 - by test (P/Y = 1/28)

8.2.2. Which document is used if document is not available

See comments in Appendix A.

8.3. Computer data base

8.3.1. Data

Y/N = 56/40 - Computerised data bank available (P/Y = 6/56)

8.3.1.1. Design data

1. Y/N = 57/4 - Support lists
2. Y/N = 45/12 - Longitudinal profiles (P = 4)
3. Y/N = 45/15 - Site maps (P = 2)
4. Y/N = 42/18 - Workshop drawings of supports
5. Y/N = 40/16 - Loading trees
6. Y/N = 33/28 - Static calculation

The value Y has been corrected by excluding answers for which the answer in 8.3.1. is no.

8.3.1.2. Actual data

1. Y/N = 48/13 - Updated support list (P = 1)
2. Y/N = 37/20 - Refurbishment / upgrading
3. Y/N = 34/28 - Updated longitudinal profile (P = 1)
4. Y/N = 33/24 - Loadings and strengths (P = 1)
5. Y/N = 27/37 - Conservation state

The value Y has been corrected by excluding answers for which the answer in 8.3.1. is no.

8.3.1.3. Historical data

Y/N = 38/24 (P/Y = 2/47).

8.3.2. What percentage is computerised ?

Table 11 - % of documents computerised		
Number answers	Median %	Mean %
60 (32 + 28)	50 (50 - 50)	51 (52 - 50)

For 13 companies all the information (100 %) has been recorded in the database.

8.3.3. Reference to a GIS (Geographical Information System) ?

Y/N = 39/47 (P/Y = 2/39).

8.4. Assessment on the basis of inspection report

1. Y/N = 97/3 - Decisions based on experienced technical personnel
2. Y/N = 52/42 - Decisions based on defined parameters

8.5. Latest design standard

1. Y/N = 86/10 - Latest design standard for upgrading (P/Y = 3/86)
2. Y/N = 59/36 - Latest design standard for refurbishment (P/Y = 5/59)
3. Y/N = 34/55 - Mix of old/new standards (P/Y = 1/34)

8.6. Design methods, correlated by test

1. Y/N = 49/48 - Design correlated by test on entire support
2. Y/N = 41/52 - Design correlated by test on individual support elements

8.7. Static analysis without test

Y/N = 47/41 - No test

8.8. Upgrading friendly design or easy to refurbish

Y/N = 63/35 - More emphasised.

The following suggestions have been made :

- to design a replaceable foundation stub ;
- to design structures with some consideration to maintenance ;
- to design a tangent tower for tension insulator sets ;

- to simplify the connections ;
- not to design to the limit ;
- to design for live line works.

Some new criteria have been mentioned : life cycle cost ; risk management : etc.

9. Experiences and solutions

This chapter refers to the particular experiences and solutions with the repair and refurbishment of supports.

More than the half of the companies (54%) have **experience** and solutions for **new bolted** connections, **strengthening** diagonals and horizontals.

Support heightening is also applied by nearly 43 % of the companies.

Reinforcement is done by strengthening corner legs, replacing or adding new members and by secondary members.

Nearly half the companies mention **intermediate solutions** awaiting a final solution (see 9.1.2 : guying, provisional corner leg, emergency structures, cranes, conductors guyed to the ground).

There are **a lot of precautions against vandalism and/or terrorism** (see 9.1.4. : fencing, anchor bolts covered in concrete, securing tower bolts, protecting corner leg with concrete, special bolts, polymeric insulators, anti-climbing devices, isolation of the place).

Many respondents explained the intermediate solution in the event of **vandalism** (or damage) (see 9.1.5. in Appendix B) as well as the permanent solution (see 9.1.6. and 9.1.7. in Appendix B).

Paragraph 9.2. summarises the answers on the **type of paintings** used for steel structures on **black steel** (only 38 % replied) as well as on **galvanised steel** (66 % replied). There is much variation in the type of paint coating as well as in the number of coats. This part of the report will refer to the comments in Appendix B.

Table 12 hereafter gives a summary of the results of the answers 9.2. to 9.4.

Very few experience of painting in tropical zones has been reported.

59 % use **lead free** paint and 45 % **soluble painting**.

21 % paint their supports **before erection**; 33 % immediately **after erection** on galvanised steel and 23% wait for weathering.

15 % **clean** the surfaces by dry sand blasting and 12 % by chemical preparation. 30 % cover the ground during cleaning or painting.

The **expected lifetime of coating** is 19 years (mean or median value).

In the first painting is delayed until significant loss of galvanizing has occurred and the steel work has become corroded, extensive preparation may be required before painting. Most supports are now constructed using galvanized steel members, which may be pre-painted prior to erection or painted just after or some time after erection.

Table 12 : gives a summary of the results of the answers to 9.2 to 9.4

TABLE 12 - PAINTING SYSTEM										
Respondent	NUMBER OF LAYERS ON		MATERIAL OF PAINTING	THICKNESS (DRY) (µm)	METHOD OF CLEANING	METHOD OF APPLICATION				EXCEPTED LIFE TIME COATING (YEARS)
	BLACK STEEL	GALV. STEEL				BEFORE ERECTION		AFTER ERECTION		
						METHOD	NR OF LAYERS	METHOD	TIME TO WAIT (y)	
1	-	?	Zn RICH	-	-	-	-	BRUSH	-	-
2	-	2	ACRYLAT	-	BRUSH	NO	-	BRUSH	10	20
3	3	2	ALKYDE	80	BRITE	BRUSH	ALL	BRUSH	0	20
4	NO	NO	-	-	-	-	-	-	-	-
5	NO	NO	-	-	-	-	-	-	-	-
6	NO	RARE	EPOXY	-	-	-	-	-	-	10
7	NO	2	POLYESTER	-	BLAST	NO	-	BR + SPRAY	0	20
8	?	?	PETROLEUM BASED	-	-	NO	-	BRUSH	WAIT	15
9	2	NO	Zn	75 + 150	BLAST	SPRAY	ALL	-	-	30
10	-	?	EPOXY	-	-	NO	-	BRUSH	0	10
11	3-4 -	- 2-3	COAL TAR EPOXY	180 to 240 120 to 180	SCRAPER	NO	-	BRUSH	3 to 10	14
12	-	RARE	-	-	-	-	-	-	-	-
13	NO	NO	-	-	-	-	-	-	-	-
14	-	-	-	-	-	-	-	-	-	-
15	-	-	-	-	-	-	-	-	-	-
16	-	-	EPOXY	-	SCRAPER	-	1	-	-	10
17	NO	1	KEELER-LONG	200	SCRAPER	NO	-	BRUSH + MITT	WAIT	20
18	1	1	KEELER-LONG	10 mil	BRUSH	NO	-	BRUSH + MITT	WAIT	15
19	-	2	ACRYLIC	100	WASH	NO	-	SPRAY	WAIT	20

TABLE 12 - PAINTING SYSTEM

Respondent	NUMBER OF LAYERS ON		MATERIAL OF PAINTING	THICKNESS (DRY) (μm)	METHOD OF CLEANING	METHOD OF APPLICATION				EXCEPTED LIFE TIME COATING (YEARS)
	BLACK STEEL	GALV. STEEL				BEFORE ERECTION		AFTER ERECTION		
						METHOD	NR OF LAYERS	METHOD	TIME TO WAIT (y)	
20	1 -	- 2	LINSEED VINYLIC	- 50 + 50	SCRAPING SCRAPING	<1970 -	ALL -	- BRUSH	0 20	3 to 5 15
21										
22	3	1	MICALEOUS	80	BRUSH	NO	-	BRUSH	0	20
23	3	1	MICALEOUS	80	BRUSH	NO	-	BRUSH	0	20
24	3	2	ALKYD-ACRYL	160	BRUSH	NO	-	BRUSH	0	12 to 15
25	3	2	ACRYL	60	HAND	NO	-	BRUSH	0	20
26	3	2	ALKYD	40 to 80	HAND	NO	-	BRUSH	1-2	10 to 15
27	2	1	SOLUBLE	120	BRUSH	SPRAY	ALL	BRUSH	0	25
28	2	1	SOLUBLE	100	SWEEPING	SPRAY	1	BRUSH	WAIT	30
29	2-3	2	PVC-ACRYL	40+80	BRUSH	NO	-	BRUSH	0	20 to 25
30	NO	2	ALKYD	-	-	NO	-	BRUSH	WAIT	10 to 15
31	NO NO	1 2	VINYL VINYL	125 40 + 125	BRUSH+SPRAY SOLVENT	NO NO	- -	BRUSH -	0 0	10 to 15 10 to 15
32	≥ 3	≥ 3	EPOXY, etc	$\geq 3 \times 40$	SOLVENT	NO	-	BRUSH	10	10
33	-	-	-	-	-	-	-	-	-	40
34	1	1	CHLORINATED RUBBER	100 to 120	WASH	-	-	BRUSH	WAIT	15 to 20
35	NO	1	VINYL-ACRYLIC	60 to 70	BLAST	SPRAY	ALL	-	-	25
36	NO	2-3	CHLORINATED RUBBER	60 to 80	SCRAPER	BRUSH	ALL	In the past	-	8 to 10
37	NO	2-3	VINYL	75+75+60	BRUSH	NO	-	BRUSH	WAIT	20 to 30

TABLE 12 - PAINTING SYSTEM

Respondent	NUMBER OF LAYERS ON		MATERIAL OF PAINTING	THICKNESS (DRY) (μm)	METHOD OF CLEANING	METHOD OF APPLICATION				EXCEPTED LIFE TIME COATING (YEARS)
	BLACK STEEL	GALV. STEEL				BEFORE ERECTION		AFTER ERECTION		
						METHOD	NR OF LAYERS	METHOD	TIME TO WAIT (y)	
38	-	-	-	--	-	NO	-	BRUSH	-	10 to 15
39	-	-	OLEUM	-	-	NO	-	-	-	10
40	≤ 4	≤ 4	-	-	-	BRUSH	1	BRUSH	0	5 to 7
41	2 -	- 3	VINYL-ACRYL	40-90	HAND	NO	-	BRUSH	WAIT	15 to 20
42	NO	NO	-	-	-	NO	-	-	-	-
43	2	2	CHLORYL	2X60	-	-	-	BRUSH	WAIT	12
44	-	-	CAMOUFLAGE	60 to 100	-	NO	-	-	0	20
45	NO	2	-	> 100	BRUSH	BRUSH	1	BRUSH	0	> 20
46	NO	2	EPOXY	2X70	BRUSH	BRUSH	ALL	BRUSH	0	20
47	NO	2	ACRYL	80	-	BRUSH	ALL	BRUSH	0	25
48	NO	NO	-	-	-	-	-	-	-	-
49	NO	NO	-	-	-	-	-	-	-	-
50	NO	NO	-	-	-	-	-	-	-	-
51	2	1	KEELER-LONG	8 mill	BRUSH-SOLVENT	NO	-	MITT	20	20
52	NO	NO	-	-	-	-	-	-	-	-
53	1	1	KEELER-LONG	6-10 mill	BRUSH	-	ALL	-	WAIT	20
54	0	1	ALUTEC	-	BRUSH	NO	-	BRUSH	WAIT	5
55	4	4	Zn	140	BRUSH	NO	-	BRUSH	WAIT	-
56	-	3	EPOXY	-	BRUSH	NO	-	BRUSH	0	10

TABLE 12 - PAINTING SYSTEM

Respondent	NUMBER OF LAYERS ON		MATERIAL OF PAINTING	THICKNESS (DRY) (μm)	METHOD OF CLEANING	METHOD OF APPLICATION				EXCEPTED LIFE TIME COATING (YEARS)
	BLACK STEEL	GALV. STEEL				BEFORE ERECTION		AFTER ERECTION		
						METHOD	NR OF LAYERS	METHOD	TIME TO WAIT (y)	
57	-	-	-	-	-	-	-	-	-	-
58	2x2 -	- 2x2	- -	60+70 80+80	-	-	-	BRUSH	10	10
59	-	-	-	-	-	-	-	-	-	-
60	5	5	-	-	-	BRUSH	ALL	-	-	15
61	-	-	-	-	-	-	-	-	-	-
62	NO	3	EPOXY	80+80+40	SOLVENT	BRUSH	ALL	-	-	25

9.1. Particular experiences and solutions

9.1.1. Repair / refurbishment

1. Y/N = 56/34 - Bolted connections
2. Y/N = 55/36 - Strengthening diagonals and horizontals
3. Y/N = 45/31 - Support heighthening
4. Y/N = 43/22 - Additional member (double profile)
5. Y/N = 41/44 - Strengthening corner legs
6. Y/N = 41/46 - Change of support top geometry
7. Y/N = 39/26 - Replacement support leg member
8. Y/N = 37/24 - Secondary member to reduce the buckling length of the leg
9. Y/N = 34/51 - Ecological precautions for drilling on site
10. Y/N = 22/42 - Stay tensions
11. Y/N = 20/43 - Deteriorated wood poles in wet air/soil
12. Y/N = 19/49 - Deteriorated wood poles
13. Y/N = 12/55 - Deteriorated concrete poles
14. Y/N = 11/76 - Welded connections
15. Y/N = 9/80 - Riveted connections

If one limits the answers to the owners of specific supports we obtain higher rates for the following types of supports (see 2.1. and the tables in the enclosures to Appendix C) :

- Guyed structures
 - stay tension (Y/N = 13/4)
- Concrete poles
 - concrete deterioration (Y/N = 8/12)
- Wood poles
 - wood deterioration (Y/N = 9/10)

9.1.2. Intermediate solution

Y/N = 47/2 (47 additional comments)

9.1.3. Experiences or solutions with repair / refurbishment

Y/N = 17/4 (17 additional comments in appendix B)

9.1.4. Precautions against vandalism

Y/N = 44/21 (44 additional comments in appendix B)

9.1.5. Intermediate solution in the event of vandalism (e.g. damage to a support leg)

Y/N = 48/9 (48 additional comments)

9.1.6. Permanent solution for a damaged corner leg at the lower part of the support shaft

Y/N = 44/2 (44 additional comments)

9.1.7. Permanent solution for a damaged corner leg at the higher sections of the support

Y/N = 33/3 (33 additional comments)

9.2. What type of painting system is used for steel supports ?**9.2.1. On black steel**

Y/N = 39/27 (39 additional comments)

9.2.2. On galvanised steel

Y/N = 69/17 (69 additional comments)

9.2.3. Additional information on painting

(Material, thickness, preparation, number of coats, method of application)

61 additional comments – See table 12 and Appendix B for more detailed information.

9.2.4. Different procedures in tropical climates

No comments received. See next clause 9.2.5.

9.2.5. Experience in tropical environment

13 additional comments – See Appendix B.

9.3. Special precautions**9.3.1. Ecological**

1. Y/N = 60/10 - Unleaded free paint material
2. Y/N = 45/18 - Soluble components

9.3.2. Painting after galvanisation

1. Y/N = 30/38 - Immediately after erection (P/Y = 4/30)

2. Y/N = 24/37 - Wait for weathering of galvanisation (3-7 years)

9.3.3. Painting before erection

- Y/N = 20/59 - Painting before erection (P/Y = 2/20)

If yes :

- Y/N = 14/18 - all layers

- Y/N = 8/17 - first layer only

9.3.4. Cleaning surfaces

1. Y/N = 16/50 - Dry sand blasting
2. Y/N = 12/51 - Chemical preparation
3. Y/N = 7/62 - Wet sand blasting
4. Y/N = 5/59 - Covering the support during blasting

9.3.5. Covering the ground during painting or blasting

- Y/N = 31/47 - Covering the ground

9.4. Expected lifetime of coating

Table 13 - Expected coating lifetime		
Number answers	Median (year)	Mean (year)
76 (38 + 38)	19 (20 – 18)	19 (19 – 18)

9.5. Coating on concrete poles

- Y/N = 3/36 - Special coating

9.6. Repair of crossarm

1. Y/N = 38/34 - Replaced totally
2. Y/N = 27/27 - Replaced tip/attachment point
3. Y/N = 24/36 - Replaced some profiles in the horizontal face
4. Y/N = 23/37 - Replaced some profiles in the vertical face
5. Y/N = 14/44 - Provided additional profiles

9.7. Support life time extension

- Y/N = 43/46 - Experience

9.8. Wood poles in tropical environment

Y/N = 8/74 - Experience

For the owners of wood poles the ratio is different (see 2.1 and the tables in the enclosure C3 to Appendix C) :

Y/N = 3/14 - Experience

10. Suggestions for future CIGRE-work

10.1. Areas to investigate

The areas to investigate in the context of CIGRE are ranked according to the preference of the responders :

1. Improvement of tools and methods for inspection (23 levels 1) (35 %)
2. Improvement of tools and methods for assessment (17 levels 1) (31 %)
3. Maintenance / upgrading friendly supports (13 levels 1) (23 %)
4. Determination / measuring of actual support strength (10 levels 1) (19 %)
5. Design improvement on footing area (10 levels 1) (19 %)
6. Determination of corrosion state of steel poles (6 levels 1) (18 %)
7. Determination of the state / strength of guys / stays (7 levels 1) (12 %).

10.2. Other areas of interest

- [2] • Preventive corrosion protection in the footing area (concrete/air) (level 2);
- Technologies against loosen of bolts by vibration (level 3) ;.
- [5] • Remnant strength of old tension bracing towers after initial deformation of some members.
- [7] • Protection of structure at structure/soil interface.
- [11] • Assessment of real residual strength of tower (if you want to upgrade the tower) (level 1).
- [16] • Guide for assessment of current condition and prediction of remaining life of components.
- [27] • A simple method for determination of the actual strengths and the quality of the material for old lines.
- [30] • Improved methods of foundation assessment (better than half cell).
- [37] • Determine corrosion monitoring of foundation (grillage) and connection (300-600 mm below ground level) with a non destructive method giving accurate (90%) results.
- [38] • State condition control methods.
- [40] • Remaining life of support (lattice, tube, concrete).
- Line refurbishment design is different compared to a new line design. Complete methodologies for line refurbishment design, issued as CIGRE recommendations for towers, foundations, conductors, insulator, fittings and earthing system could be useful for OHTL designers.
- [52] • Determining state of corrosion of lattice tower grillage anchors (level 3).

- [54] • Wind load determination.
 - Gust response factor.
 - Impact factor (conductor broken).
 - Weight span determination.
- [55] • The area of special interest is pile foundation. One of our piles at 66 kV support failed. It has been stated that piles carry only static loads, because the effect of pulsating loads and of vibration on pile foundations has not yet been adequately investigated.
- [56] • Effect of industrial pollution on supports (level 1).
- [57] • Determining state/strength of concrete poles (level 3).

10.3. Conclusion

WG B2.08 will try at least in the future to investigate and to improve tools and methods for inspection and to follow up the paragraphs of increased interest.

CIGRE WG B2.08

OHL SUPPORTS

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

APPENDIX A

QUESTIONNAIRE SENT ABROAD

June, 2003

Note : In this revision, some titles have been reviewed and some wordings have been improved. However, the questions have not been modified.

Assessment of
existing
Overhead line supports
(Towers, guyed structures and poles
for rated voltage above 45 kV)

QUESTIONNAIRE

The content of this questionnaire is as follows :

1. Introduction
2. General information on existing supports
3. Criteria for management of supports
4. Inspection philosophies
5. Type and causes of defects
6. Inspection tools and methods
7. Inspection reports
8. Assessment of inspection data
9. Experiences and solutions
10. Suggestions for future CIGRE work

1. Introduction

1.1 Informative Remarks

CIGRE Working Group B2.13 (**Management of existing overhead lines**) has been presented with the task of determining the present service experience (failures) and component inspection (defects) of overhead lines and to compile guidelines on :

- inspection philosophies,
 - the diagnostic tools available for inspection and,
 - the assessment and management of the collected data,
- in order to provide management guidance to utilities for the maintenance, refurbishment and, if appropriate, upgrading of the lines (CIGRE Technical Brochure no 175).

A relationship between support original design, its inspection, assessment and remedial works is demonstrated in a flow chart (enclosure 1).

As a part of this exercise various Working Groups of Study Committee B2 ("Overhead Lines") responsible for the different components making up an overhead line have been requested to provide the basic data for WG B2.13. To this end **Working Group B2.08 (Overhead Line Structures)** has prepared the attached questionnaire, which you are requested to complete, to collect information about the practices and experiences of utilities in the field of inspection and assessment of your **existing supports** and the practical works you undertake on their life extension refurbishment and upgrading. The questionnaire returns will be collected and reported to CIGRE and ultimately combined, by WG B2.13, with those for other line components, and lead to a comprehensive overview for complete overhead transmission and distribution lines.

In the following pages this questionnaire pose different questions which are considered to be appropriate to **all** OHL structures irrespective of type of material, whether steel angle or hollow section lattice supports or steel, concrete or wood poles. The member connections may be riveted, bolted (coarse or friction) or welded.

For your assistance in completing the questionnaire you are requested to consider the guidelines contained in item 1.2. Item 1.3 provides various definitions of the terms employed to ensure consistent returns.

1.2 Guidelines for completing the questionnaire

Please note the following:-

- The scope of this questionnaire is limited to **existing supports**.
- Please observe the definitions given in chapter 1.3
- It is understood that some of your procedures and practices may differ, sometimes significantly, depending on the type of support addressed (steel support, pole, etc.). To ensure consistency and accuracy of the returns you are requested to address each type of support by photocopying the relevant pages of the questionnaire, identifying the relevant type of support (or supports if more than one type) at the **top** of each page, and answer each separately. You are also referred to the "notes" in Item 2.1 of the questionnaire.

- This questionnaire provides space for any comments that you may consider relevant for a correct understanding of you response(s). All comments will be highly appreciated. If the space provided is insufficient for a complete response please add extra sheets as you require. You are requested to identify any additional pages included with your response as enclosures and cross reference the additional sheet(s) to the main page of the questionnaire.
- Most questions can be replied simply by “Yes” or “No” however some entries response requires a “Hit list of importance 1....5”. Please refer to each section for the interpretation of the codes 1 to 5.

We would like to thank all participants for the time spent answering this questionnaire, which is understood to be comprehensive. Any additional comments, technical or otherwise, are welcome.

After receiving your answers to this questionnaire we would request your permission to contact you for any additional clarifications that may be necessary. The results of this exercise will be advised to you by the issue of an ELECTRA report.

1.3 Definitions

Assessment of supports	The process of interpreting information produced from the inspection of supports and data on service experience etc. in order to produce an assessment report .
Assessment report of supports	An assessment report can be used to <ul style="list-style-type: none"> • estimate the present structural strength or condition of the supports and / or ; • predict the residual life either at the original design loads or at higher loads resulting from upgrading or line uprating.
Distribution	Here deemed to be 45 up to ≤ 150 kV
Inspection of supports	This is the total process of detecting, measuring or estimating those characteristics or symptoms that contribute to the physical condition of the support elements using either destructive or non-destructive methods to enable the production of an inspection report .
Inspection report of supports	An inspection report is a summary of the data collected by the inspection. It forms a basis for the assessment .
Life extension of supports (retrofit)	Extensive renovation of supports without restoring their original design strength.
Maintenance of supports	Routine conservation and small/local repair.
Refurbishment of supports	Extensive renovation or repair of supports to restore their intended design strength.
Support	All types of supports or poles whether self-supporting, guyed or chainette structures, irrespective of type of material.
Transmission	Here deemed to be > 150 kV.

Upgrading of supports:	Increasing the original strength of supports to resist increased loads.
Upgrading of a line:	Increasing the electrical characteristics of a line due to, for example a requirement for :- <ul style="list-style-type: none">- higher transport capacity- larger electrical clearances Upgrading may require upgrading of supports.

2 General information on the existing supports
(which you refer to in this questionnaire)

2.1 What type of support(s) do you refer to in this questionnaire

- self-supporting lattice steel (tower).....

Yes

No

- guyed lattice steel support (e. g. chainette type)

Yes

No

- self supporting hollow steel section support.....

Yes

No

- steel tubes or folded hollow steel support (poles) (x).....

Yes

No

- concrete supports (poles) - prestressed (x).....

Yes

No

- concrete supports (poles) - not prestressed (x)..

Yes

No

- wooden supports (poles) (x).....

Yes

No

Notes:

a) If your responses to the following questions differ between the above identified support types please copy the relevant pages of this questionnaire and complete them for each type of support (see top of this page).

b) Please also identify the **material** of the above type of support, e.g.

- lattice with hot-rolled steel angles
- lattice with cold-formed steel angles
- etc.

c) Please (x) indicate whether or not with guys / stays.

Please also advise the type and material of crossarm.

.....

.....

.....

2.2 For this type of construction please provide an estimate of the quantity of supports within your utility you refer to:

- less than 1,000.....

- more than 1,000 up to 10,000.....

- more than 10,000.....

- if possible please give specific details.....

.....

.....

2.3 Please attach any additional information that you think will assist the WG in their research. For instance, please provide / attach a **distribution (graph) of support ages** of your referred, or national, overhead line network. If no figures are available, please make an estimation.

.....

.....

.....

.....

.....

		voltage level	
		≤150 kV	> 150 kV
Yes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

* NOTE : "1" most frequent, "5" very seldom.		Hit list of importance 1.....5 *	
		≤150 kV	> 150 kV
		voltage level	
3	Criteria for management of supports		
3.1	Which of the following are considered the most important criteria for management decisions relating to maintenance / refurbishment / upgrading.		
	- symptoms of defects	<input type="checkbox"/>	<input type="checkbox"/>
	- type and sources of defects	<input type="checkbox"/>	<input type="checkbox"/>
	- existing condition of support when compared against original strength	<input type="checkbox"/>	<input type="checkbox"/>
	- probability of collapse.....	<input type="checkbox"/>	<input type="checkbox"/>
	- network performance (inventory of network / statistics of defects)	<input type="checkbox"/>	<input type="checkbox"/>
	- available budget	<input type="checkbox"/>	<input type="checkbox"/>
3.2	Do you perform the following on your supports? (see definitions, 1.3)	≤150 kV	> 150 kV
	- maintenance		
	• routine conservation	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	• occasional local repair	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- life extension	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- refurbishment	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- upgrading	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>

* NOTE : "1" most frequent, "5" very seldom.		Hit list of importance 1.....5 *	
		≤150 kV	> 150 kV
3.3	What is your main reason(s) for performing maintenance_? (Please generalise and read together with items 3.4 and 3.5 below) Is it to remedy: - minor corrosion - paint deterioration - vegetation in the area of the support - deformation of elements - loose bolts - other reasons, please explain:.....		
3.4	What is your main reason(s) for performing refurbishment or life extension (please generalise)? Is it to remedy:		
3.4.1	- extensive corrosion: • due to industrial atmosphere • due to normal weathering - other reasons (e. g. electrostatic), please explain:		
3.4.2	- deformation of the crossarms - deformation of the support shaft - deformation of support elements due to vandalism - global support deformations (for example due to bolt hole tolerance, or other) - inclination of the support (for example due to differential foundation settlement) - deformation of the support due to uneven foundation settlements - connection to foundation (e. g. local corrosion) .. - other reason(s), please explain:		

* NOTE : "1" most frequent, "5" very seldom.		Hit list of importance 1.....5 *	
3.5	What is the main reason(s) for you to perform upgrading on supports (please generalise)? Is it to provide: <ul style="list-style-type: none"> - higher ground clearances (e. g. change of road system, etc.) - larger internal electrical clearances - electromagnetic impact demands - installation of special equipment (e.g. fibre optic or telecommunications, such as antenna or microwave dishes etc.) - higher transport capacity: <ul style="list-style-type: none"> • change of conductor • higher conductor operating design temp..... • higher voltage level - higher meteorological loads/actions - other reasons, please explain:		

		voltage level	
		≤150 kV	> 150 kV
4	<u>Inspection philosophies</u>		
4.1	Do you inspect your supports regularly? (item 4.1 is to be read in conjunction with item 4.2).....	Yes No	<input type="checkbox"/> <input type="checkbox"/>
4.1.1	Do you regularly inspect your supports visually (this sub-item 4.1.1 is to be read in conjunction with sub-item 4.1.2) :- Please note, for clarification period [year] = $\frac{1}{\text{frequency}[1/\text{year}]}$		
4.1.1.1	for the general lines of your grid:	Yes No	<input type="checkbox"/> <input type="checkbox"/>

if "Yes" please indicate the period of inspection and sampling rate in the table below (please refer to the example in enclosure 2).

Method of Inspection	≤ 150 kV		> 150 kV	
	period	sample	period	sample
- from car	.....years	.....%	.....years%
- from ground	.....years	.....%	.....years%
- by climbing	.....years	.....%	.....years%
- from helicopter	.....years	.....%	.....years%
- other (please specify)	.....years	.....%	.....years%

.....
.....

4.1.1.2	for strategic lines (e.g. connection lines) of your grid:	Yes No	<input type="checkbox"/> <input type="checkbox"/>
---------	--	-----------	--

if "Yes" please indicate the period of inspection and sampling rate in the table below (please refer to the example given in enclosure 2).

Method of Inspection	≤ 150 kV		> 150 kV	
	period	sample	period	sample
- from car	.....years	.....%	.....years%
- from ground	.....years	.....%	.....years%
- by climbing	.....years	.....%	.....years%
- from helicopter	.....years	.....%	.....years%
- other (please specify)	.....years	.....%	.....years%

Please comment :

.....

.....

.....

		voltage level	
		≤150 kV	> 150 kV
4.1.2	Do you inspect your supports regularly in a more detailed manner (e.g. not only visually, but with diagnostic equipment)? If "Yes" Please give details	Yes <input type="checkbox"/>	<input type="checkbox"/>
	No <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.2	Do you inspect your supports only occasionally (say oriented after a damage-event)? If "Yes" please explain why regular inspections are not considered necessary.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
	No <input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.3	Are minimum qualifications required for the inspectors / linesmen performing the support inspection?	Yes <input type="checkbox"/>	<input type="checkbox"/>
4.3.1	If "Yes" : Please give a short description	No <input type="checkbox"/>	<input type="checkbox"/>
4.3.2	Do you have an established training programme ?	Yes <input type="checkbox"/>	<input type="checkbox"/>
	If "Yes" and if possible, please attach a copy of the training programme	No <input type="checkbox"/>	<input type="checkbox"/>
4.4	What is the percentage of your maintenance / refurbishment budget expended on supports in relation to your overall budget for the complete transmission line grid?%%
	If applicable, please qualify the figure(s) quoted		
4.5	Do you organise maintenance/refurbishment using your own personnel?	Yes <input type="checkbox"/>	<input type="checkbox"/>
	If "Yes" : Please comment	No <input type="checkbox"/>	<input type="checkbox"/>
4.6	Are your maintenance / refurbishment activities		

		voltage level	
		≤150 kV	> 150 kV
performed by other companies (contractors)? If "Yes" : Please comment:	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
4.7 Do you generally have any permanent condition monitoring? If "Yes" : Please comment:	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>

* NOTE : "1" most frequent, "5" very seldom.		Hit list of importance 1.....5 *	
		≤150 kV	> 150 kV
5	<u>Type and causes of defects</u>		
5.1	What are the typical identified fault(s) of the supports in your referred network (please generalise)?		
5.1.1	- faults of protection painting	<input type="checkbox"/>	<input type="checkbox"/>
	- faults of corrosion of structural steel	<input type="checkbox"/>	<input type="checkbox"/>
	- faults of stays, guys, connections (missing/deformed)	<input type="checkbox"/>	<input type="checkbox"/>
	- faults on bolts/nuts/washers (loose, missing)	<input type="checkbox"/>	<input type="checkbox"/>
	- default in welds	<input type="checkbox"/>	<input type="checkbox"/>
	- faults at the connection to the foundation..... (deteriorated, deformed)	<input type="checkbox"/>	<input type="checkbox"/>
	- deformation of elements of the main support	<input type="checkbox"/>	<input type="checkbox"/>
	- deformation in the crossarms	<input type="checkbox"/>	<input type="checkbox"/>
	- reduced tension in stay wires	<input type="checkbox"/>	<input type="checkbox"/>
	- wood deterioration	<input type="checkbox"/>	<input type="checkbox"/>
	- concrete deterioration	<input type="checkbox"/>	<input type="checkbox"/>
	- faults on small / thin members due to corrosion (especially in tropical countries).	<input type="checkbox"/>	<input type="checkbox"/>
	- other, please explain:	<input type="checkbox"/>	<input type="checkbox"/>
		
		
5.1.2	Please indicate the estimated percentage of supports <u>without</u> defect and comment: %%
		
		
5.2	If you have experienced a complete support(s) out of service (collapse), what is the main cause; please generalise.		
	- due to cascade	<input type="checkbox"/>	<input type="checkbox"/>

* NOTE : "1" most frequent, "5" very seldom.	Hit list of importance 1.....5 *	
	≤150 kV	> 150 kV
- due to wind loading (on conductor and support)	<input type="checkbox"/>	<input type="checkbox"/>
- due to ice loading	<input type="checkbox"/>	<input type="checkbox"/>
- due to wind and ice loading	<input type="checkbox"/>	<input type="checkbox"/>
- due to conductor breakage	<input type="checkbox"/>	<input type="checkbox"/>
- due to material defects	<input type="checkbox"/>	<input type="checkbox"/>
- due to erection / construction fault	<input type="checkbox"/>	<input type="checkbox"/>
- due to vandalism	<input type="checkbox"/>	<input type="checkbox"/>
- due to delayed preventive maintenance or refurbishment	<input type="checkbox"/>	<input type="checkbox"/>
- due to fatigue (conductor vibration).....	<input type="checkbox"/>	<input type="checkbox"/>
- other reasons, please explain:	<input type="checkbox"/>	<input type="checkbox"/>
.....		
.....		
5.3 What type / cause of corrosion do your supports suffer from?		
- normal weathering	<input type="checkbox"/>	<input type="checkbox"/>
- industrial pollution	<input type="checkbox"/>	<input type="checkbox"/>
- maritime site (salt corrosion)	<input type="checkbox"/>	<input type="checkbox"/>
- continuous high humidity in tropical zones.....	<input type="checkbox"/>	<input type="checkbox"/>
- as above but in temperate zones	<input type="checkbox"/>	<input type="checkbox"/>
- gap corrosion (resulting in pack rust)	<input type="checkbox"/>	<input type="checkbox"/>
- inter-crystalline corrosion of material	<input type="checkbox"/>	<input type="checkbox"/>
- heavy vegetation growth (in tropical environment)	<input type="checkbox"/>	<input type="checkbox"/>
- as above but in temperate zone	<input type="checkbox"/>	<input type="checkbox"/>
- other reasons, please explain:	<input type="checkbox"/>	<input type="checkbox"/>
.....		
.....		

* NOTE : "1" most frequent, "5" very seldom.		Hit list of importance 1.....5 *	
		≤150 kV	> 150 kV
5.6	Identify the type of deformation, if any, found within the support crossarms - deformation at the tip / attachment point <input type="checkbox"/> <input type="checkbox"/> - rotation / torsion of the crossarm <input type="checkbox"/> <input type="checkbox"/> - bending in the vertical plane <input type="checkbox"/> <input type="checkbox"/> - bending in the horizontal plane <input type="checkbox"/> <input type="checkbox"/> - local deformation <input type="checkbox"/> <input type="checkbox"/> - others, please explain <input type="checkbox"/> <input type="checkbox"/>		
5.7	Have you experienced a broken member of a crossarm (upper girder) by fatigue due to aeolian vibration of the member or conductor or both in resonance. Please give information relating to a) bolt hole tear and b) member slenderness ratio. Yes <input type="checkbox"/> <input type="checkbox"/> No <input type="checkbox"/> <input type="checkbox"/>		

6 Inspection tools and methods

		voltage level	
		≤150 kV	> 150 kV
6.1	What method(s) do you generally utilise for inspection of supports?		
	- destructive methods (out of service)	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- non-destructive methods.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
	Please give details of your general practice:	No <input type="checkbox"/>	<input type="checkbox"/>
		
		
		
6.2	Do you use special tools for the inspection of the supports, such as? (see 6.2.1 to 6.2.3)	Yes <input type="checkbox"/>	<input type="checkbox"/>
	(please comment and explain on a separate sheet of the enclosure and give acceptance criteria, if any)	No <input type="checkbox"/>	<input type="checkbox"/>
6.2.1	for steel supports, i. e. tools for measuring:		
	- deflection of supports and torsion of supports..	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- geometry of steel (lattice) structure	Yes <input type="checkbox"/>	<input type="checkbox"/>
	(e.g. photo-grammeters)	No <input type="checkbox"/>	<input type="checkbox"/>
	- paint thickness meter.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- galvanise thickness meter.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- steel corrosion metrology (x).....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- support leg corrosion detector (x).....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- guys/stay wire corrosion detector (x).....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>

		voltage level	
		≤150 kV	> 150 kV
- in case of steel poles or steel pipe structure.... (endoscope device)	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- tool for tension measurement of stays.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
Others, please describe;.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
.....	No	<input type="checkbox"/>	<input type="checkbox"/>
.....			
(please refer to Item 6.2.4)			
6.2.2 for concrete supports, i.e. such tools as :			
- deflection.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- corrosion detector (x).....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- concrete quality detector (sclerometer).....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- concrete quality impact device (Schmidt hammer)	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- surface carbonisation (chemical).....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
Others, please describe;	Yes	<input type="checkbox"/>	<input type="checkbox"/>
.....	No	<input type="checkbox"/>	<input type="checkbox"/>
.....			
6.2.3 For wooden supports, i. e. such tools as :			
- hammer test.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- drilled cores.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- resistograph (x).....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- decay drill (Sibert/Shannon) - (x).....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>

		voltage level		
		≤150 kV	> 150 kV	
	Others, please describe;	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	.....	No	<input type="checkbox"/>	<input type="checkbox"/>
			
6.2.4	Note(x) : Please give information on a separate sheet(s) and reference to any publication if you have any experience of these specialist device(s).			
6.3	Do you utilise special laboratory examination on materials, such as :			
	- metallurgical analysis.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
		No	<input type="checkbox"/>	<input type="checkbox"/>
	- chemical analysis.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
		No	<input type="checkbox"/>	<input type="checkbox"/>
	- electron-microscopic analysis.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
		No	<input type="checkbox"/>	<input type="checkbox"/>
	- steel properties (e. g. yield, impact etc.).....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
		No	<input type="checkbox"/>	<input type="checkbox"/>
	Others, please describe;.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	.....	No	<input type="checkbox"/>	<input type="checkbox"/>
			
6.4	Please give your comment on the value or advantages of such detailed analyses. What is your experience and in what circumstances are they found specially useful?.....			
			
			

7 Inspection reports

7.1 Do you use **checklists** for inspection of the general state of your supports ?

Note : Please give a short description and / or attach a copy of a typical checklist(s) to the enclosure:

.....

7.2 Do you employ an EDP tool (electronic field book) to work on a check list without any paper?

		voltage level	
		≤150 kV	> 150 kV
Yes	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
No	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>

Please provide any information that gives details of the records you retain for the inspections performed according to your response under items 6.1 and 6.2. If possible attach examples.

.....

7.3 During inspection are records taken of any of the following deformations ?

- displacement at the top of the support ?
 (global deformation)

- displacement of nodes ?
 (global deformation)

- deformed / damaged profiles (and number) ?..

- location of deformed / damaged profiles ?

		≤150 kV	> 150 kV
Yes	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
No	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
No	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>

		≤150 kV	> 150 kV
- degree of deformation ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- reduction In cross section ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- kind of profile deformation ?			
• bending ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
• buckling ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
• torsion ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
• local deformation ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
• cracking ?	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- other, please describe.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
.....	No	<input type="checkbox"/>	<input type="checkbox"/>
.....			
.....			
7.4 During inspection do you differentiate between the various states of corrosion attack on your supports, by reference to :-			
- surface extent of corrosion	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- depth of corrosion attack.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- location of corrosion attack.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
- others, please comment	Yes	<input type="checkbox"/>	<input type="checkbox"/>
.....	No	<input type="checkbox"/>	<input type="checkbox"/>
.....			
.....			

		≤150 kV	> 150 kV
<p>if “Yes” to any of the above, please provide information on the criteria employed. For example do you :</p>			
7.4.1	categorise the extent of surface corrosion by a set of defined criteria, i.e.	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- low corrosion attack, say 0-3% of the surface..	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	(please enter your actual value).....%%
	- medium corrosion attack, say 3 to 10% of the surface	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	(please enter your actual value).....%%
	- high corrosion attack, say above 10%.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	(please enter your actual value).....%%
7.4.2	regarding the depth of attack, for example :-		
	- excessive surface oriented rust (say 90 % profile thickness intact)	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- local rust attack with dents (say 70 % profile thickness intact)	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- totally exposed hole in profile	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	Please comment:		
		
		
		
		
		

7.5

Do you categorise the results of your inspection activities for each support in your inspection report identifying the importance / urgency of deficiencies found? For example like the following sequence :

	≤150 kV	> 150 kV
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>

Category	Apparent consequences
1 = good	no repair required without span of time
2 = problematic	repair required in a defined span of time
3 = not good	repair later without urgency but a.s.a.p.
4 = critical	repair required at once
Remark: The type of repair will be defined under "Assessment"	

Please comment regarding your actual practice and describe how you categorise defects:

.....

.....

.....

.....

.....

.....

.....

.....

8. Assessment of inspection data (incl. data handling)

Note: clause 8.1 and 8.2 refer to line documentation
 clause 8.3 and 8.4 refer to data handling
 clause 8.5 and 8.6 refer to assessment
 clause 8.7 to 8.8 refer to basic considerations

		voltage level	
		≤150 kV	> 150 kV
8.1	Available documents		
8.1.1	Are you normally in possession of comprehensive line documentation, such as :		
	- site maps/longitudinal profiles?.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- support lists? (tower list).....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- workshop drawings for supports...	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- loading tree?.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	- statical calculation of the supports		
	• steel quality data?.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	• steel profiles and bolt data?.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	• support geometry?.....	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
	• in case of concrete supports quality of concrete and reinforcement data	Yes <input type="checkbox"/>	<input type="checkbox"/>
		No <input type="checkbox"/>	<input type="checkbox"/>
8.1.2	If not please state reasons:		
		
		
8.1.3	Please specify for which percentage of your system / grid you have :-		
	- all information.....%%
	- some information.....%%
	- no information.....%%
	Please comment:		
		
		

8.1.4 Please advise whether you are normally in possession of :

- as-built support drawings
- modification (i.e. actual) support drawings

	voltage level	
	≤150 kV	> 150 kV
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>

Please comment as necessary referring to the voltages (< 150 kV or > 150 kV) and type(s) of construction addressed :

.....

.....

.....

.....

.....

8.2 Load carrying capacity of existing supports

8.2.1 If documents **are** available, what methods/tests are normally used to compare the actual support capacity with the nominal state? Please describe your normal methods.

- by calculation.....
- by test.....
- other (please explain).....

	voltage level	
	≤150 kV	> 150 kV
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>

8.2.2 If documents are **not** available, which methods/ tests will be used to determine support loading capacity?
 - please explain

.....

.....

8.3 Do you have a **computerised** data base (data bank) of supports? (Refer to enclosure 1)

If "Yes" see next item

Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>

8.3.1 Does your inventory of support documents consist of :-

8.3.1.1 design data

- site maps
- support lists.....
- longitudinal profiles
- workshop drawings
- loading trees
- statical calculations
- other, please give details on the contents of your database (if possible please attach example)
.....
.....
.....

8.3.1.2 actual data₁ such as :-

- up-to-date support list.....
- updated longitudinal profiles.....
- conservation state of supports.....
- loadings and support strength capacities.....
- support refurbishment, upgrading data.....
- other line components (excluding supports) data, please give details:.....
.....
.....

8.3.1.3 history data₁ regarding (b) above and comment:

-
-
-
-
-
-

	voltage level	
	≤150 kV	> 150 kV
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>
Yes	<input type="checkbox"/>	<input type="checkbox"/>
No	<input type="checkbox"/>	<input type="checkbox"/>

		voltage level	
		≤150 kV	> 150 kV
8.3.2	What percentage of your referred type(s) of support is already computerised as per data base (a), (b) and (c) above? Please provide comments:%%
8.3.3	Do you have items being referred to under (a), (b) and (c) incorporated into a GIS (graphical information system)? Please comment:	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
8.4	How do you make your assessment on the basis of the inspection report?		
8.4.1	Decisions based on evaluation of inspection report by experienced technical personnel Please comment	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>
8.4.2	Decisions are based on defined parameters	Yes <input type="checkbox"/> No <input type="checkbox"/>	<input type="checkbox"/> <input type="checkbox"/>

If “Yes” please give details

.....

		≤150 kV	> 150 kV
8.5	Do you generally employ your latest (new) or your original (old) design standard (national standard or regulation / specification) as a basis for : Refurbishment ?		
	New	<input type="checkbox"/>	<input type="checkbox"/>
	Old	<input type="checkbox"/>	<input type="checkbox"/>

		≤150 kV	> 150 kV
b) Upgrading .?	New	<input type="checkbox"/>	<input type="checkbox"/>
	Old	<input type="checkbox"/>	<input type="checkbox"/>
Is there a case when you employ a mix of the latest and original standards	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
If "Yes" please explain			
.....			
.....			
.....			
.....			
8.6 Have your design methods, standards and / or regulations been correlated by tests on :	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
an entire support tested either in-situ or at a test station ?			
<i>(continued)</i>			
8.7 Alternatively to 8.6: do you generally rely on static analysis (without support test)?.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
If "Yes" Please comment			
.....			
.....			
.....			
8.8 Are you of the opinion that more emphasis should be given at the design stage to a support that is upgrading-friendly or easy to refurbish ?.....	Yes	<input type="checkbox"/>	<input type="checkbox"/>
	No	<input type="checkbox"/>	<input type="checkbox"/>
Note: Such a support design may ultimately result in less difficulties (technically, in time, in funds) for future modifications / repairs.			
If "Yes" please comment :			
.....			
.....			
.....			
.....			
.....			
.....			

9 Experiences and solutions

9.1 Solutions **after** inspection and assessment

9.1.1 Do you have particular **experiences** or **solutions** with the repair / refurbishment of supports with respect to :

(If possible please attach / provide details)

- bolted connections?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- riveted connections?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- welded connections?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- strengthening of corner legs?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- strengthening of diagonals and horizontals?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- In case of strengthening of support leg, what do you prefer :-		
• replacement ?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
• secondary members ?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
• additional member (double profile) ?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- Do you have to take precautions during on-site steel drilling (due to ecological reasons)	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- increase tower height ?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- change of support-top geometry?.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- deteriorated concrete poles (cracks and corroded bars)...	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- deteriorated wooden poles above ground	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- as above, but in the wet air/soil area of support.....	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- stay tensions	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>

9.1.2 What intermediate solution do you typically employ during the complete or partial support replacement ?

.....

.....

9.1.3 Please provide any other information concerning your **experiences** or **solutions** with the repair / refurbishment of supports

.....
.....
.....
.....

and especially with respect to the following:

9.1.4 - What precautions do you take to protect your supports against vandalism ?

.....
.....
.....
.....

9.1.5 - In the event of damage occurring to a profile (e.g. support leg) by vandalism what intermediate solution(s) do you employ ?

.....
.....
.....
.....

9.1.6 - What permanent solution do you have for a damaged corner leg -
• at the lower part of the support shaft (e.g. by vandalism)?.....

.....
.....
.....
.....

9.1.7 • at higher sections of the support?.....

.....
.....
.....
.....

9.2 What type of painting system do you use for steel supports, please comment:

9.2.1 on black steel?.....

.....
.....
.....
.....

9.2.2 on galvanised steel ?

.....
.....
.....
.....

9.2.3 Please give additional information on :-

- material of paint

.....
.....
.....
.....

- thickness of layer(s).....

.....
.....
.....
.....

- preparation of surface.....

- number of coats.....

- method of application (by brush or spray).....

9.2.4 In tropical climates do your procedures differ? If so please give details (as (b) above)

9.2.5 Do you have experiences (positive or negative) on various types of paints in a tropical environment (for instance epoxy resin)?

9.3 Special questions on coating of steel supports:

9.3.1 What ecological precautions do you make, regarding the choice of paint material?

- unleaded.....

Yes

No

- soluble components

Yes

No

Please Comment:

9.3.2 How long do you wait for galvanised structures **before** protecting with an additional protective coating?

- Immediate coating after support erection.....

Yes

No

- Wait for weathering of galvanisation before coating (typically 3 to 7 years)

Yes

- other, please comment

No

9.3.3 Do you paint **before** erection?.....

If "Yes"

Yes

No

- all layers ?

Yes

No

- first layer only

Yes

No

<p>- If you answered "Yes" to painting before erection please advise what precautions you take for electrical continuity..... </p>		
<p>9.2.4 How do you clean / prepare the steel surfaces ? - Dry sand blasting..... - Wet sand blasting..... - Do you cover the support during blasting?..... - Chemical preparation of surface (prior)..... - other, if "yes" please comment</p>	<p>Yes No Yes No Yes No Yes No</p>	<p><input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/></p>
<p>9.3.5 Do you cover the ground when painting / repainting or blasting ? If "Yes" please comment</p>	<p>Yes No</p>	<p><input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/></p>
<p>9.4 What is the expected / achieved lifetime of your referred coating? Please comment</p>	<p>Years</p>	<p><input type="checkbox"/><input type="checkbox"/></p>
<p>9.5 Regarding concrete poles: Do you apply a special coating of surface against deterioration? If "Yes" please give information / comment:</p>	<p>Yes No</p>	<p><input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/></p>
<p>9.6 Have you previously had to repair deformed crossarms (refer to 5.6). Did you : - replace totally? - replace some profiles in the vertical faces ? - replace some profiles in the horizontal faces ?</p>	<p>Yes No Yes No Yes No</p>	<p><input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/> <input type="checkbox"/><input type="checkbox"/></p>

- provide additional profiles ?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- replace crossarm tip / attachment points ?	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
- other, please explain	Yes	<input type="checkbox"/>
.....	No	<input type="checkbox"/>
.....		
.....		
9.7 Do you have any experience in performing works to extend the life of the supports (see definitions 1.3). Please comment:	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
.....		
.....		
.....		
.....		
9.8 Do you have any experiences for the use of wooden poles in a tropical environment ? Please comment and state the type of wood.	Yes	<input type="checkbox"/>
	No	<input type="checkbox"/>
.....		
.....		
.....		
.....		

“1” - Most Important, “5” least important		Hit list of importance 1.....5 *	
		≤150 kV	> 150 kV
10	<p><u>Suggestions for future CIGRE work</u></p> <p>Which areas of interest, related to the topic of this questionnaire, would you like CIGRE to investigate in more detail in the future? For instance regarding :-</p> <ul style="list-style-type: none"> - improvement of tools and methods for inspection - improvement of tools and methods for assessment (data handling) - determination/measuring of actual support strength .. - foundation (soil) interface: design improvements on footing area of supports - Maintenance / upgrade friendly supports ? - determining the state of corrosion of steel poles - determining state / strength of guys / stays - other areas of interest (please state which) <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p> <p>.....</p>		

CIGRE SCB2/WG08 thanks you for your kind attention to this questionnaire!
If required, please add your extra pages for your comments or copies as enclosures to this questionnaire.

Date/signature

Your name and department
(please printed)

Your company address
(incl. phone/fax)

.....

.....

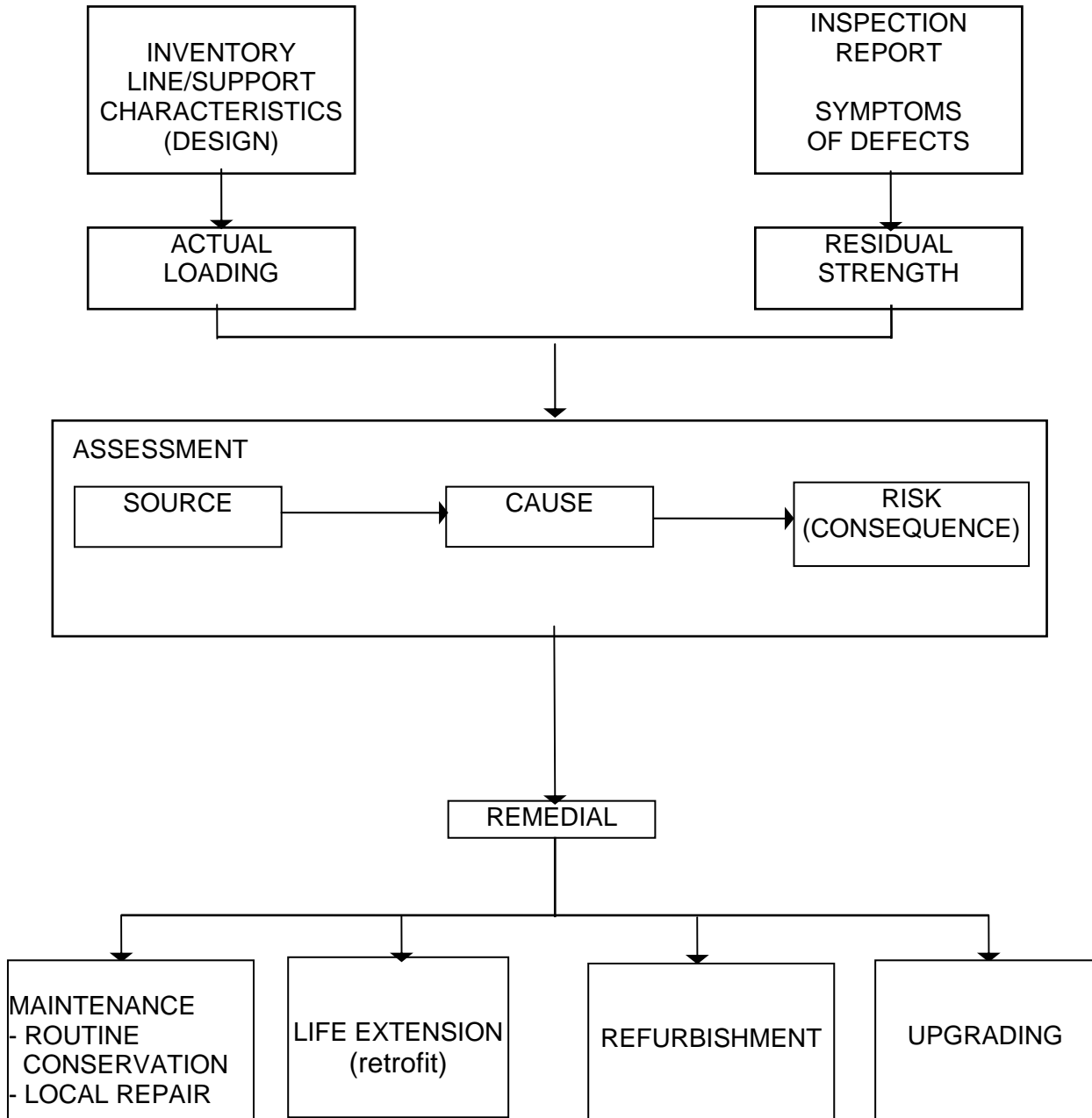
.....

.....

.....

Enclosure A1

**INTERACTION BETWEEN SUPPORT DESIGN,
INSPECTION AND ASSESSMENT**



Enclosure A2EXAMPLEfor an answer on item 4.14. Inspection philosophy4.1 Do you inspect your supports regularly?

(item 4.1 is to be read in conjunction with item 4.2)

4.1.1 Do you regularly inspect your supports visually

(this sub-item 4.1.1 is to be read in conjunction with sub-item 4.1.2)

a) for general lines of your grid:

	< 150 kV		> 150 kV	
	period	sample	period	sample
- from car	- years	- %	- years	- %
- from ground	5 years	50 %	5 years	100 %
- by climbing	- years	- %	- years	- %
- from helicopter	2 years	50 %	2 years	100 %

b) for strategic lines (e. g. connection lines) of your grid:

	< 150 kV		> 150 kV	
	period	sample	period	sample
- from car	- years	- %	- years	- %
- from ground	2 years	50 %	1 year	100 %
- by climbing	- years	- %	- years	- %
- from helicopter	1 year	100 %	1/2 year	100 %

CIGRE WG B2.08

OHL SUPPORTS

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

APPENDIX B

**INVENTORY OF THE COMMENTS
ON THE QUESTIONNAIRE**

June, 2003

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1. Introduction

This Appendix B includes all the comments made by the respondents on the different answers.

All those comments provided by the respondents worldwide are classified according to the subclauses of the questionnaire. Right brackets refer to the identity number of the respondent (confidential), the round brackets to the priority level attributed by the correspondent to the corresponding item.

One did not keep the trivial comments (e.g. “no known damage”).

Generally we did not modify the wordings of the respondent in order to keep the nuance of the statements.

This document does not evaluate the comments provided. The WG B2.08 is not responsible for the rightness of the comments. However the multitude of comments stand for a richness in worldwide experience in the assessment of existing OHL supports.

Finally the Appendix C includes statistical results of the answers to the questionnaire.

2. General information on the existing supports

See Appendix C for detailed information.

3. Criteria for management of supports

3.1. Most important criteria for management decisions

No comments.

3.2. Management decisions on supports

Comments :

- refurbishment/life extension : only after assessment defects mentioned in § 3.4 [11];
- wood pole and crossarm replacement [18];
- local repairs : seldom; life extension : sometimes; also thermal rating [27];
- life extension, refurbishment, upgrading in very rare cases [32].

3.3. Reason for maintenance

Other reasons :

- loss of galvanizing (1) [5];
- corrosion at ground / air interface (1) [5];
- electrical performance lightning (1) [6];
- insulation checks (1) [6];
- ground line rot of wood pole (1) [9];
- paint deterioration but without any corrosion (because repainted if residual lifetime is less than 2 years) (1) [11];
- reinforcement or upgrading (3) [11]
- vandalism (1) [12];
- substitution of overhead ground wire by OPGW [13];
- woods poles : rot, woodpecker damage, corroded guy wires and anchors, loose guys and leaning structures, broken ground wires (1) [18];
- crack corrosion (1) [28];
- inspection of insulators : corrosion of cap and pin type [30];
- check wood poles for decay (1) [30];

- wood pole rot (1) [34];
- to keep clearance to ground and to avoid constructions under the line (1) [35];
- major corrosion (2) [37];
- electrical performance (1) [37];
- corrosion protection [41];
- stolen elements (2) [41];
- see patrol checklist (condition of rust on tower; danger sign; number sign; loose bolts; foundation soil erosion around tower, etc...) [51];
- prevention of collapse due to vandalism and theft of support members and bolts [55];
- flooding due to construction of dams (1) [56];
- insulation; vandalism (1) [60];
- wood deterioration (1) [61];
- repair of damaged conductor due to vibration. To replace broken insulators [62].

3.4. Reason for refurbishment / life extension

3.4.1. Other causes for extensive corrosion :

- extensive corrosion due to normal weathering at ground level (1) [4];
- worn attachment points (2) [4];
- foundation corrosion : all towers have direct embedded steel grillages with some old plate fan towers (1) [5];
- cost optimization (2) [6];
- foundation steel corrosion (soil interface) [7];
- life extension (by painting) where sufficient strength remains despite corrosion; refurbishment (by replacing or reinforcing member) if corrosion damage is too great for paint systems [7];
- ground line rot of wood pole (1) [9];
- extensive corrosion does not arrive. Painting is anticipated [11];
- sea coast atmosphere [12];
- stray DC current from cathodic protection on pipe lines affecting anchors (1) [18];
- crack corrosion (1) [28];
- repairs to anti climb-guards (3) [30];
- change wood poles if decayed [30];
- wood pole rot (1) [34];

- extensive corrosion due to saline atmosphere (1) [36];
- vibration and galloping [38];
- uprating [42];
- cracks in the concrete (2) [46];
- foundations (4) [53];
- damage to tower leg due to high pH level in the ground (3) [54];
- an additional maintenance strategy is the welding of bolts and nuts on members to discourage theft (3) [55];
- capacity voltage uprating (5) [56];
- marine pollution – corrosion [62].

3.4.2. Other causes for corrosion than pollution and weathering

- foundation steel corrosion (soil interface) (2) [7];
- foundation inclination due to ground raising (seaports) or depression filled by dumping (3) [11];
- extensive corrosion does not arrive if the structure is repainted in time (2) [11];
- localized cracking at bolt + holes on arm tension members (1) [18];
- wood poles : pole and crossarm wood decay (to replace) (1) [18];
- extension of line operation till official permission for renewal of line is received [26];
- connection to excavated foundation (1) [28];
- foundation inadequacy [31];
- bad quality of concrete (pad and chimney) [38];
- deformation of crossarm and support shaft due to ice / snow load [38];
- terrorist activities (1) [48].

3.5. Reason for upgrading

Other reasons :

- NA [4];
- reinforcement to upgrade tower to new wind code requirements (3) [7];
- higher meteorological loads/actions after wind storms in 1990 (4) [11];
- we don't need these providence critically [12];
- replacement of GW by OPGW (3) [26];
- snow and ice < 150 kV (1) [27];

- new standards [39];
- to avoid galloping [40];
- lines are "uprated" with the same tower type to increase maximum operating temperature of conductors [49];
- on two occasions wooden poles had to be upgraded to lattice supports due to flooding of streams being traversed [55];
- change in soil / terrain conditions [62].

4. Inspection philosophies

4.1. Regular inspection

4.1.1. Regular visual inspection

Comments :

- method of inspection is currently reviewed [4];
- detailed (T = 1 y) and fast (T = 0,3 y) helicopter patrol (sample = 40 %) [7];
- inspection level is a function of identified risk, whether structural, vegetation or encroachment [8];
- wood poles are also influenced by wood species and termites [8];
- check of earthing (T = 10 to 20 y) : sample = 5-10 % [11];
- check of painting (2 y before normal painting); sample = 10 - 20 % [11];
- from car only in urban areas [16];
- river crossing is strategic location [16];
- period for climbing wood poles : 15 years [17];
- we are implementing Reliability Centered Maintenance (RCM). So expert inspection may change [18];
- lines that cannot be patrolled by helicopter are controlled on foot. As required use detailed helicopter inspection using stabilized binoculars in liaison of climbing [18].
- carrying out of additional patrol of strategic lines depending on known condition of plant and customer concerns [18];
- wood poles : thermal imaging camera survey from helicopter [18];
- alternatively from ground and helicopter [27];
- thermal imaging camera survey from a helicopter [30];
- lines are constructed with reference to common standard, so a major attention is paid to those lines which show greater problems of interference with the surrounding environment [32];
- no wood pole lines in the category of strategic lines [34];
- special inspection schedule of paint system by climbing [36];
- distance attendant : period = 4 years (6 years for strategic lines), sample = 100 % [44];

- for long lines car inspection is replaced by helicopter inspection [48];
- for lines connected to power plants helicopter frequency is twice [48];
- third component to the 3 year cycle is inspection of towers by forestry personnel while maintaining right of way [49];
- 120 kV wood poles every 10 years perform ground-line inspection [51];
- inspection by car is very convenient and quick, but the problem is that less than 14 % of the grid is readily accessible by car due to insufficient maintenance of access roads [55];
- inspection of wood poles by climbing after 15 years [61].

4.1.2. Regular more detailed inspection

Comments :

- ultrasonic detection for cracks in steel poles [4];
- half cell tests [5];
- detailed area inspection [5];
- pilot project to train crew to assess below ground corrosion [7];
- copper sulfate half cell for grillage foundation [7, 8];
- by climbing the supports [12];
- effects of corrosion rate using electrode [15];
- thermography, buzzing of insulators, spacer dampers (10 % / year) [16];
- infrared helicopter[18, 20, 52];
- slow helicopter patrol using stabilized binoculars [18];
- only for repainting [27];
- measuring corrosion [28, 35], loose bolts [35];
- measurement of layer thickness. Adhesion test [36];
- earth electrode resistance measurement [39];
- only for corrosion protection [41];
- wood pole : sonic test pole ground line [51];
- FLIR [52];
- inspection by climbing for wood pole deterioration after 15 years [61].

4.2. Only occasional inspection (after damage-event)

Comments :

- trend data available [5];
- yes, except as above (see 4.1.2.) [8];
- depends on risk : mainly vegetation growth and easement encroachment [8];
- after events of high winds, bushfires, lightning where a trip has occurred or local knowledge suggests that this would be prudent [8];
- until now we have had only one remarkable failure due to unusual meteorological events [26];
- before upgrading, or if we have doubts about foundations [30];
- fault patrols [37];
- only for transmission lines and after special meteorological circumstances [42].

4.3. Line Inspectors

4.3.1. Minimum requirements for line inspectors

Comments :

- special supervised and educated inspectors for steel lattice towers and line equipment [2];
- currently being addressed [4];
- currently linesmen are used [5];
- line experience [6, 50];
- linesman inspection skills are part of training linesman training, on the job training [7];
- job training for general inspection [8];
- small training course for copper sulfate half cell [8];
- must have erection and maintenance work experience [10];
- qualified personal for painting inspection [11];
- our crew are submitted to training [12];
- technician of intermediate level [13];
- there is a periodic practical training [15];
- lineman school; high school education; in-house training [16];
- power line technician [17];

- line maintainer or technician who has worked in the field and has had specialized training [18];
- experienced lineman [19];
- specific knowledge of equipment (specific training) [20];
- experience [22];
- experience is required [23];
- the inspectors must have experience in erection of towers [25];
- corresponding to qualification of a certified workman, eventual with additional engineering support [26];
- yes, for corrosion and thickness of painting [27];
- hand out a check-list [28];
- qualified line workers [29];
- linesman trained / experienced in steel tower works [30];
- wood poles : inspectors are qualified : linesmen who are also trained in wood pole decay detection [30];
- every year control staff attends a training course on new techniques of inspections, new legislation, etc. [32];
- linesmen would have undergone training modules 2/3 months in each year until qualified as linesman [34];
- wood poles : linesmen would have undergone training modules 2/3 months in each year until qualified as linesman [34];
- linesmen trained in requirements of inspection standards [37];
- skilled linesmen [38];
- certificate [39];
- minimum 5 years experience in OHTL [40];
- qualified electricians [41];
- they must have experience with the line works [43];
- specially on-the-job trained linesmen [45];
- know-how and experience [46];
- all inspectors and linesmen are trained by our company [48];
- all linesmen are trained to inspect all types of structures [49];
- experience as linesman [50];
- trained linesmen perform inspection [51];
- former linesman [52];

- most of linesmen undergo a lines course at the company training school specializing on wooden supports; none for lattice supports [55];
- 1). ordinary level education – 2). minimum of 7 years on HV line work [56];
- the inspector has to pass the line inspector training module [62].

4.3.2. Training program for line inspectors

Comments :

- contractors responsibility [5];
- small training course for half cell [8];
- some items we refresh, some skills are developed on the job and taken as a base skill [8];
- special safety procedures, tests and qualification [11];
- corrosion and wood pole assessment [18];
- we offer internal draining programs and occasional seminar [26];
- see attached form [36];
- training program is confidential [48];
- proprietary and confidential [49];
- multi-media and virtual reality training [62].

4.4. Maintenance / refurbishment budget in % to overall budget OHL network ?

Comments :

- depends on annual line-investment program and project permissions [3];
- wood pole testing - Replacement program implemented [9];
- the figures quoted are approximate [10];
- not relevant : very few new lines (except modifications & upgrading) [11];
- steel structures 5 % : wood poles : 10 % [16];
- overall budget includes right-of-way management vegetation control [18];
- overall budget includes right-of-way management & vegetation control [18];
- maintenance 10 %; refurbishment : 75 % [19];
- % of revenue budget [30];
- however OHL is inspected as a system [34];

- 400 kV lines have quad bundles, so relatively more attention has to be paid to conductors, spacers, clamps, etc. [36];
- not possible to quantify since not clear what is included in the overall budget (maintenance, new projects, writing off ?) [45];
- the other 80 % is spent on replacing other line hardware and way-leave maintenance [56].
- steel tubes : there is little maintenance work done on such supports (only 5 %) [56].

4.5. Maintenance / refurbishment organized by own personnel ?

Comments :

- management in house [6];
- field work could be contracted out [6];
- part of general inspection [8];
- poles as part of linesmen work [9];
- tower stub leg/concrete muff interface [9];
- anti-climbing guard [9];
- we have our skilled personnel to perform maintenance work [10];
- yes, only maintenance and small repairs and not for refurbishment [11, 27];
- these kinds of examinations are useful only for investigation after damage event [15];
- field staff assess the plant with direction from a central department. Work is carried out by permanent staff and staff from the union hiring hall which are released after the work is complete [18];
- in a normal frame [22];
- for small / local repair [24];
- our own personnel has the needed know-how for maintenance [25];
- in most cases the work is done by specialized outside companies and the supervision is done by our own personnel (staff) [26];
- climbing inspections / line patrols with own staff. Painting done with contractors [30];
- wood poles : minor works [30];
- not for tower painting and major refurbishment [31];
- in the future it may be possible to give this task to Contractors [32];
- yes, but very seldom (only for maintenance) [35];

- often in combination with personnel from Contractors. Works are also carried out for other utilities [36];
- we have our own line department [39];
- for changing of elements, bolts, etc, not for corrosion protection renovation [41];
- we have crew for EHV OHTL [42];
- we have two maintenance crews [45];
- enough number of trained personnel [48];
- support staff makes workload for field groups with in-house computer system [49];
- 25 % by company; 75 % by Contractors [50];
- we use our own linesmen [51];
- we use own personnel to establish schedule for maintenance [53];
- line patrols and bolt and member replacement work is done through out the year. It is considered cheaper to use our own staff [55];
- not 100 % is done within, because of limited resources, outside contractors are sometimes used [56];
- for < 150 kV and steel tubes only maintenance is organized : our line crews are well knowledgeable on this [56];
- own personnel : 40 %; contractor : 60 % [57];
- own live line team [62].

4.6. Maintenance / refurbishment activities performed by Contractors ?

Comments :

- special contractors for painting, foundations, steel structures, conductor regulations, etc. [2];
- by another subsidiary and exterior contractor [4];
- 1/3 is done by company employees [6];
- inspection and structural work completed in house. Specialist tasks e.g. high specialized painting and cathodic protection are contracted out [7];
- some wood pole inspections have been carried out by contractors as well as some vegetation clearing [8];
- collapsed tower replacement [9];
- tower elevation for thermal upgrade [9];

- we have our skilled personnel to perform maintenance work. Some major maintenance / refurbishment activities are sometimes performed by the Contractors [10];
- yes, only for refurbishment and not for maintenance [11, 27];
- yes, sometimes depending of the work to be done [12];
- only in case of OHTL failure – accident [13];
- we generally plan and supervise maintenance / refurbishment activities [15];
- work is shared with private Contractors [16];
- not at this time but are moving in this direction [18];
- only specific maintenance or refurbishment performed by Contractors [20];
- yes, if it is more difficult [22];
- maintenance is done by Contractors under direction of our own personnel [25];
- reference is made to item 4.5, however small jobs (like change of insulators) will be done by our own personnel [26];
- performed by various erecting companies [28];
- qualified companies for erection of overhead lines [29];
- wood poles : major refurbishment by Contractors [30];
- not for maintenance but refurbishment and tower painting by Contractors [31];
- maintenance : 50 % by own personnel; refurbishment : 99 % by contractors [35];
- often in combination with personnel from Contractors. Works are also carried out for other utilities [36];
- have been outsourced for 10 years [37];
- larger tasks/projects are subcontracted [39];
- 30 % (70 %) by own personnel [40];
- for corrosion protection refurbishment and larger refurbishment works [41];
- not generally [49];
- 25 % by own personnel; 75 % by contractors [50];
- only painting is performed by contractors [51];
- wood poles : ground-line inspection performed by contractors. Some 120 kV wood pole work is performed by contractors [51];
- no, but for the past two years way-leave maintenance is being performed by contractors [55];
- maintenance is done in house but refurbishment is contracted out (OHTL) [56];

- specialized line erection contractors (for a limited range of work) [62].

4.7. Permanent condition monitoring

Comments :

- by means of scheduled inspections [1];
- insulator current leakage detectors [5];
- insulation / pollution monitors [6];
- corrosion monitors [6];
- no, except monitoring conductor vibration [17];
- in the frame of our internal operation assurance system [26];
- tension sensors (on very few supports) [35];
- condition assessment contracts [37];
- only for reliability of the system [48];
- permanent condition monitoring are done in specific cases only [62].

5. Type and causes of defects

5.1. Typical identified faults

5.1.1. Other faults :

- crossarm axes due to steel corrosion (5) [5];
- painting and corrosion problems are at or below the ground line where steel is in contact with the soil [7];
- we have problems with vandalism and our guy wires were every time loose of tension [12];
- woodpeckers' damage in wood poles in some areas [16];
- deformation in cross arms-steel : importance 5; wood : importance 3 [16];
- wood poles : anchors pulling out of the ground, and broken ground wires have caused pole fires [18];
- earthing (2) [26];
- terrorist activities (1) [48];
- contaminated insulators (4) [52];
- steel members are stolen; corrosion is serious in industrial areas [56];
- guyed lattice steel support : vandalism is rife [56];
- corrosion of earth straps [62].

5.1.2. Comments on the estimated percentage of supports without defect

- steel poles : major defects are from ground line corrosion [4];
- % relates to age and location [6];
- based on visual/climbing inspection [9];
- existing lines < 150 kV are old and lines > 150 kV are almost new. Maintenance is regularly done [10];
- emphasis is on critical defects. Many of the defects are of a minor nature and do not need immediate attention [18];
- we have a strong quality control due construction and due maintenance control [25];
- most defects are paint. Minor corrosion [30];
- wood poles : no decayed poles at present time. Some minor corrosion of crossarms [30];

- 400 kV-grid is younger in age than 150 kV-grid [36];
- the percentage is such because of corrosion. Regarding general condition of supports it would be 99 % [41];
- we do not have extreme weather conditions [42];
- all structures experienced higher than anticipated corrosion of weathering steel [49];
- most of the defects are due to theft and are a prominent in localized areas [55];
- the supports without defect are far away from industrial areas [56];
- steel tubes : they are more robust than other type of supports : 99 % without defect instead of of 80 or 90 % for other type of supports [56];
- marine corrosion is a common problem on lines situated near coastal areas [62].

5.2. Main cause of collapse of support (out of service)

Other causes :

- external damages (3) [5];
- tractor collision [5];
- incorrect maintenance practice [5];
- vandalism is an isolated case [6];
- wood poles hit by car (1) [9];
- storm, river erosion, landslide (3) [10];
- public contact or motor vehicle accident (4) [18];
- galloping (2) [19];
- accident with car (5) [24];
- failure of foundation (2) [28];
- wind and ice loading caused failure of Malone type foundation [30];
- we have found a few cases of very slender base members (diagonal of K frame on 220 kV towers) broken due to vibration in exposed areas [34];
- land- and snowslide [38];
- combination of extra loadings and initial erection faults or material defects, after 5 ... 25 years of maintenance [40];
- rockfall, landslip (4) [45];
- avalanches (3) [45];

- avalanches (1) [47];
- tornado damage (2) [49];
- airplanes (5) [50];
- tornado (4) [51];
- car crash (4) [54];
- breaking down of foundation (1) [61];
- weather (floods, rain) [62].

5.3. Type / cause of corrosion

Other causes :

- temporary accumulation of rain water [1];
- acidic soil in some areas [5];
- corrosion of steel in contact with soil (1) [7];
- tower in depression filled with water (4) [11];
- wood poles : below ground anchors [18];
- grillage footing below ground surface (1) [18];
- utilization of weathering steel, which has remained in some cases without corrosion protection [26];
- wood poles : decay of timber at ground line and occasionally at the pole top [30];
- mainly surface corrosion of small members due to industrial and coastal pollution [31];
- geothermal volcanic ash (2) [37];
- corrosion of weathering steel (1) [49];
- loss of anode (3) [50];
- pH level in ground [54].

Comments :

- high humidity solved by regular afforesting [11];
- gap corrosion solved by mastification [11];
- no inter-crystalline corrosion if painting is applied long before corrosion attack [11].

5.4. Reason of corrosion problem

Other reasons :

- aggressive soils [5];
- wind and temperature : cyclic moisture variation accelerating corrosion [6];
- design permitting buried steel (1) [7];
- poorly performing paint system (1) [7];
- old age, where zinc has been broken down typically greater than 30 years [8];
- environment [11];
- I think that the corrosion of our galvanized supports is because the age of the lines [12];
- low or delayed painting (1) [31];
- inadequate quality of paint applied (1) [36];
- old tower loosing galvanizing over many years [37];
- poor galvanizing [38];
- mixing of ordinary (painted) and Corten (not painted) steel (4) [40];
- corrosion of galvanized steel because of silicon-enriched steel (1) [41];
- old age [46];
- most corrosion problems on core wire (ACSR & OPGW) ≤ 150 kV; very few corrosion on > 150 kV : too new towers (1) [52];
- pH, wind, ground, life extension (3) [54].

5.5. What is affected by the corrosion problem ?

Other items :

- bolts and nuts, difficultly accessible for painting and with poor visibility [11];
- very few corrosion problems [16];
- only guys and anchors [18];
- bolts of Corten steel [24];
- we do not use supports with stays [35];
- connections with large gussets or flanges (2) [40];
- mainly bolts and nuts made of black steel to discourage theft and/or rusting. We have not experienced corrosion on stays [55].

5.6. Type of deformation in the crossarm

Other reasons :

- we have few problems [16];
- no signaled deformation [31];
- crossarm deformation is very seldom. So we do not have any data (5) [35];
- fatigue cracking in wind braces [49];
- this mostly on the 55 kV supports where few members were found snapped on the upper crossarm [55].

5.7. Member of a crossarm broken by fatigue (due to aeolian vibration of the member or conductor or both in resonance)

Comments :

- not for upper girder, but bracing member damage due to vibration crack at stress concentration at bend/cut near end [7];
- localized cracking at bolt holes on arm tension members (see § 3.4). The slenderness ratio is > 300 [18];
- only on hardware [37];
- established loose bolts and oval holts [39];
- refurbishment of crossarm damaged by too heavy vibrations, oscillations, galloping; installation of bolts with double nuts in horizontal girder and extra angles in vertical plane [40];
- yes, because of damper failures causing vibration [48];
- quite possibly. This member would not meet requirements of current design guidelines for slenderness ratio [49];
- before conductor was attached [51].

6. Inspection tools and methods

6.1. Methods used for inspection of supports

Comments :

- most frequently visual inspection [10, 16, 18, 25, 31, 43];
- visual inspection [18, 29, 30, 36, 41, 42, 53, 56, 57];
- half cell tests; excavations [5];
- removal of elements and laboratory examination [6];
- copper sulfate half cell for grillage foundation [8];
- visual climbing inspections [9];
- non destructive methods are very seldom [11];
- all our inspections are visual [12];
- pole testing, loss of metal [18];
- refer to attached inspection forms [18];
- destructive methods are not normal but we have carried out structure testing to failure [18];
- visual inspection and measurement thickness of zinc [19];
- corrosion and tensile force control [20];
- development of a new magnetic measurement and tension tests of steel [27];
- half cell foundation tests [30];
- wood poles : hammer test and ultra-sound investigations [30];
- visual grading of corrosion, galvanizing thickness test, paint thickness test, paint adhesion test (cross cut) [31];
- elcometer for remaining galvanizing [34];
- wood pole rot testing [34];
- destructive methods *in* service [37];
- tower leg integrity monitor (Cormon) for legs (support leg corrosion detector) [37];
- thickness measurements [49];

- FLIR [52];
- ground line boring (wood pole) [52];
- steel tube : visual inspection and pole sounding [56];
- binoculars [57].

6.2. Special tools for inspection of supports

6.2.1. Steel supports

Other tools:

- random sampling using metallic strips [6];
- special wire corrosion cells utilizing different materials [6];
- we rarely use tools for measuring during inspection [12];
- hammer test [28];
- ultrasonic thickness gauge [49];
- ground resistance meter [51];

Comment :

- stay : dynamometer or clamp on tension indicator [18].
- steel corrosion metrology generally on Corten steel [26];

6.2.2. Concrete poles

Other tools :

- visually only [8];
- chloride test. The above refers to concrete substation structures only [31];
- specific laboratory analysis [40].

6.2.3. Wood poles

Other tools :

- Mattson drilling machine [30];
- "purl" ultrasonic rot locator used to check for decay [30];
- ultra sound [34];
- ultrasonic rot locator [37];
- sonic test [51];
- wood supports are inspected using the sounding method i.e. hit with a hammer and listen for hollowness [55].

6.3. Special laboratory examination of materials

Other examinations :

- no.

Comments :

- chemical analysis of corrosive products only [11];
- where necessary for special studies [37];

6.4. General comments on laboratory examinations

Advantage of analyses; when are they useful ?

- establishment of corrosion rates [6];
- these services are used for failure investigation or during life assessment [8];
- for particular cases, or for exceptional behavior [11];
- we rarely use laboratories to examine the materials of supports during the operation of the line [12];
- used for expertise on specific problems mainly for hardware [16];
- establishment of corrosion rate, ductility characteristics at critical locations and strength [18];
- systematically after damage [20];
- very useful in case of quality control of material before constructing [25];
- metallurgical and chemical analysis only after break down [27];
- mainly in case of line component failure in order to assess, if necessary, the reason of the failure [32];
- in case of severe corrosion under the paint layer to get information on strength and remaining life [36];
- to determine the state of decay of paint, zinc and zinc alloy layers [36];
- very useful [37];
- after collapse; for very old lines; for lines without documents [40];
- we determined the need for corrosion protection renovation of hot galvanized supports with chemical and electron microscopic analysis [41];
- only before erection and not on tower in service [42];
- only during production of materials [48];
- able to determine root cause [50];

- these analysis are performed in our own laboratory of failed components. This is performed on as a need basis [51].
- such analyses assist in compiling condition-based maintenance programs [56];
- only occasionally after damage [61].

7. Inspection reports

7.1. Use of checklist for support inspection

Comments :

- see check-list attached [4, 17, 18, 24, 28, 29, 34, 36, 37, 40, 51, 55, 62];
- tower type, span, insulators, grounding, spacer dampers, stockbridges [1];
- for painting and structural inspection [11];
- assessment and Maintenance Guides [20];
- only corrosion [22];
- corrosion classification according to the national standard [27];
- information is recorded in special Data Bank for statistical evaluation (pilot project) [27];
- vegetation, foundations, earthing, defects on elements, stolen elements, verticality, corrosion protection, sign-plates [41];
- we use checklists according to the given numbers [48];
- proprietary and confidential [49];
- handheld computer system [49];
- electronic; confidential [49, 50];
- number and identity of missing tower members highlighted, extent of corrosion mentioned and extent of paint work required also noted [56];
- steel tubes : also condition of crossarms [6];

7.2. Details of the records

Comments :

- see attached sheets [29, 37, 40];
- data loaded into a hand held data recorder and downloaded to a PC [8];
- used on a trial basis [16];
- all information on the structure assessment forms are retained [18];
- keep records on paper file [19];
- we prepare life-cycle-files where actualized as-build-lists and descriptions of failures (type and extension of failure) are handled. From this line-based documentation the maintenance planning is derived [26];

- see checklists for inspection from ground and from helicopter [29];
- computer database logs all "events" such as painting, steelwork changes, minor maintenance (e.g. muff repairs), inspection dates and findings [30];
- wood poles : database logs all "events", which include inspection date, pole condition, fitting and insulator condition, etc. [30];
- for wood pole line condition assessment and for refurbishment programs [34];
- just started with it [36];
- condition assessment is contracted out [37];
- proprietary and confidential [49];
- confidential [50];
- as from June 1999 we will be producing job cards based on the defects found and these will be computerized for cost-capturing and calculation of manpower utilization factors, etc. [56].

7.3. Kind of records

Other records :

- flange deformation [11];
- presence, position and legibility of mandatory interdiction panels (tower nr., text, telephone) [11];
- presence of warning panels with identification of circuits [11];
- presence of anti-climbing guards [11];
- condition of climbing bolts or angles [11];
- records taken only when required [16];
- based on visual observation; measurements of deformation only taken if considered critical [18];
- normally damage is caused by farming equipment [19];
- pictures [20];
- deformation would only be at base level due to animal or machinery interference [34];
- displacement of support top, occasionally in case of heavy loads and soil deformation or displacement in the vicinity of towers [36];
- visual qualitative inspection [52];
- reduction in cross-section areas for foundation stubs are recorded probably because they are very critical and much easier to see without using special equipment [55].

7.4. Differentiation of corrosion attack

Other references for differentiation :

- painting before first rust damages [3];
- depth of corrosion attack only if very deep [11];
- corrosion is a minor problem [16];
- half cell measurement [18];
- in accordance with the national standard [27];
- wood poles are classified "decayed" or "suspect" according to the degree of decay. Min. residual strength to be 85 % [30];

7.4.1. Categorizing extent of corrosion surface

Comments :

- 0,05 % surface attack before first painting and 1 % (≥ 150 kV) to 2 % (70 kV) after first painting [11];
- see attached sheet [18, 37];
- high corrosion attack : 20 % of the surface for Corten Steel [26];
- visual estimation [30].

7.4.2. Categorizing depth of corrosion attack

Comments :

- pitting (light or severe) [7];
- the depth of corrosion attack is not a criterium because the thickness of galvanization is very variable along the surface [11];
- the depths of attack are categorized on two levels :
 - < 50 % profile thickness intact;
 - > 50 % profile thickness intact [58].

7.4.3. General Comments

Comments :

- excessive surface rust : 95 %; local rust attack : 75 % [2];
- corrosion does not arrive before painting [11];
- refer to inspection form attached to questionnaire reply [18];

- normally visual judgment and by photographs (no %) [19];
- corrosion attacks are categorized before painting [27];
- visual grading is used but is not categorized by percentage areas [31];
- no serious problems regarding corrosion as all supports are factory-galvanized [35];
- see attached list [36];
- also examined thickness of "pack out" in joints [49];
- four categories of condition of rust on tower : none; light; moderate, severe [51];
- we do not categorize the degree and type of corrosion probably because this phenomenon attacks a very small number of our structures : i.e. around one substation. It is nearly not a threat and does not warrant such efforts [55].
- we do not put down percentages because our lines staff still require training on this [56];

7.5. Categorizing results of inspection activities identifying the urgency of repairs

Comments :

- category like above (7.4.2.); consequences identical [2];
- usually additional investigation is required to ascertain the extent of defects versus residual asset life before major repairs are decided [4];
- initial identification from air, then detailed follow up from ground [5];
- all defects identified, then prioritized for whole line at once after inspection [5];
- use is made of photographic plates to guide inspectors in visual grading of galvanized steel corrosion [6] :
- 2) longer term;
- 3) non-urgent but action required;
- 4) critical : replace ASAP [7];
- included with conductor, hardware and basement defects on patrol report, inputted into maintenance management system for issue of work order. Assigned priority :
 - attention within 1 month;
 - attention within 1 year;
 - can be deferred beyond 1 year [9];
- only two categories: 1) and 2) [11];
- painting decided in 1 or 2 years before normal painting [11];

- estimation of residual cross-section, etc [11];
- visual inspection results in a list of damages which needs repair at once or in a few months and an estimate of the extent of corrosion [19];
- 1) good = no repair required;
- 3) not good = repair later without any urgency;
- 4) critical = repair with urgency [20];
- is being developed [22];
- see category 4 = critical [24];
- the urgencies are fixed line-wise. Because of the regularity of the controls we have a good knowledge of the actual state of the line (being described in our live-cycle-files). The efficiencies in the foundations areas are defined in a catalogue by an urgency criteria from 1 - 13. However defects in the tower area have to be described in words as exact as possible [26];
- pilot project in future [27];
- same 4 categories [28];
- wood poles : we are starting to treat suspect wood poles using boron rods and paste. This has not yet been done on 132 kV system wood poles [30];
- reporting has not been formalized and depends on visual estimate by the linesmen. In general, our towers are in moderate to good condition. We have a rolling painting program [30];
- classification of surface attack by comparison with photographic scale reporting different degrees of corrosion [32];
- 3 = not good; 4 = critical [34];
- wood poles : 3 = not good; 4 = critical [34];
- use of thickness category of galvanization [35];
- 0 = good, ..., 3 = urgent [36];
- see attached sheets [36, 37, 51];
- category 2 = problematic; 3 = not good; and 4 = critical (from 7.5.) [38];
- normal – urgent – critical [42];
- yes, 4 categories of 7.5.a [48, 54];

- level I - repair ASAP - 2 weeks max;
II - repair within 6 months;

III - repair when able [49];

- 1) do something;
- 2) defer [50];
- in terms of painting, refer to need to continue for established criteria [53];
- we categorize same defects as above [54];
- when the inspection report is submitted by the lines-foremen, the Engineer categorizes the repair works, i.e. which should be done immediately and those which can wait. There is no separate job card as such. Comments are made on the file copy and sent down to the work group [55];
- defects are categorized as :
 - still good;
 - bad;
 - urgent attention required;
 - close monitoring required [56].
- For < 150 kV defects are categorized as 7.5. [56].

8. Assessment of inspection data

8.1. Available documents

8.1.1. Available line documentation

No comments.

8.1.2. Comment if no documents

- considered as not necessary [1];
- lines built by contractors over the years lack complete records [4];
- we inspect only with the checklist; we have all documents of the line at office [12];
- missing for some old lines [16];
- details are retrieved from files as required [18];
- for older 110 kV OHL we possess documentation only partially [41];
- not important[50];
- as we have only two suppliers of concrete poles, quality of concrete and reinforcement data are verified seldom [57];
- older lines might have not as detailed records available as for new lines [62].

8.1.3. Part of network covered by documents

Comments :

- old lines (1916) are worst for information [5];
- some information/documents lost during world or independence war [10, 25];
- profile maps are not updated with new constructions built under the existing line [11];
- information missing of old network [20];
- some towers are built since 50 to 70 years [22];
- only related to old lines which are planned to get demolished [26];
- we are in the process of collating all of this and will update all records in due course [37];
- some files seem to have been misplaced due to the transfer of assets from one company to another [55];
- no information : these are modifications in the grid that have not been updated [57].

8.1.4. Available documents on line modification

Comments :

- as-built support drawings as to actual setting after hole depth optimization and construction [5];
- to date all design and most construction has been done in house from 1916 to present [5];
- "shop details" drawings provided by line contractor for all tower members fabricated enable replacement of damaged tower members as required [7];
- modification drawing following tower test of tower type if failure occurs [9];
- operation only ≤ 110 kV [26]
- we can get drawings from utility in most cases. However records of foundations are frequently not available [30];
- this is a normal practice [55];

8.2. Load carrying capacity of existing supports

8.2.1. Verification if documents are available

Other verifications :

- by computer simulation [4];
- each tower series has been tested [5];
- NBR, ASCE, ANSI [15];
- test for new designs [16];
- national standard [30];
- by calculation if the reduction in cross-section necessitates to do so [36];
- original tower test reports [37];
- paper copies of original design usually available. Analytic models generally have to be built [52];
- test contracted out [56];

8.2.2. Which method is used if document is not available

Comment :

- complete new static [2];
- field measurement of member sizes and model support [4];
- it does not arise [25, 31, 40];
- field measurements : evaluation of actual state → however additional calculation was only required in one case until now [26];
- very seldom : only by inspection on tower location [27];
- measure wood poles on site [30];
- by contractor analyses [37];
- by measuring the elements; by material tests (yield); by computer analyses [40];
- we take the measures of profiles and on the basis of them we made static calculations [41];
- model construction [50] ;
- by the load tree or conductor and ground wire features [54];
- this comparison is not usually done [57];
- by calculation [61];
- on old structures, mechanical tests were done and structures re-analyzed [62].

8.3. Computer data base

8.3.1. Data

8.3.1.1. Design data

Other data :

- design data only paper recorded [7];
- computerized data base identifying structure location and conductor clearances [18];
- site maps, longitudinal, profiles ... in preparation [26];
- all above but *not* in electronic database form [31];
- not yet [36];
- proprietary and confidential [49];

- workshop drawings, loading trees, static calculations stored by contractors [61].

8.3.1.2. **Actual data**

Other data :

- conductors, clamps, insulators, connectors [2];
- foundation, conductors, hardware [11, 20];
- support shape, foundation, conductors [20];
- we have computerized site maps, support lists, and some important longitudinal profiles [25];
- complete regulation of conductor (line-wise) taking into account also the strand setting of conductor [26];
- only defects are in the data bank [27];
- insulator and fittings [31];
- tower coordinates [37];
- terrain data, sag tension data, etc [54].

8.3.1.3. **Historical data**

Comments :

- data of any change [2];
- historical data is not always accurate [18];
- historical data depends on support type and age [20];
- will be established in next future [27];
- only data from collapses [40];
- yes: data files and ongoing work [53];
- where changes have been done, the database has been updated as well [56].

8.3.2. **What percentage is computerized ?**

Comments :

- still to be validated in process [4];
- in process of doing using specific software [4];
- 0 % for a) and c); 10 % for actual data [7];
- currently being implemented [9];
- 100 % for painting [11];

- structure locations and clearances are computerized in data base [18];
- without history data [20];
- only database of general OHL data (support type, height, weight : 100 % [41];
- a database will be created in 1999 using IT2000 [56].

8.3.3. Reference to a GIS (Geographical Information System)?

Comment :

- still to be validated [4];
- GIS is being commissioned at present and then a comparison can be made between design information and assets that have been modified [8];
- yes, structure locations and type, as well as site maps [18];
- we are beginning with "small world" [24];
- there is a possibility to call the drawings of the details of the support due to the digitalization of the drawings [26];
- in progress [27];
- route maps and support locations only [31];
- GIS in the preparing phase [41];
- locations [46];
- we have full information about support strengths [48].

8.4. Assessment on the basis of inspection report

8.4.1. Experienced technical personnel

Comments :

- damage or corrosion is usually obvious and we proceed on replacement or life extension/refurbishment as required [7];
- based on technical audits [11];
- training to assess degree of corrosion is required as well as pole testing [18];
- see 7.5. [19];
- in progress [27];
- wood poles : hammer / borer tests backed up with "purl" ultrasonic test [30];
- we evaluate the experience of qualified technical personnel [48];
- evaluated on a case by case basis [52].

8.4.2. Based on defined parameters

Comments :

- need for action is self evident [7];
- see CIGRE report 22-302 of Paris Session 1994 [11];
- priority based decision [16];
- importance of the line. Reliability and customer need. Structure importance. Public and worker safety [17];
- for example : damage classification of foundations [24];
- only partly, for example we have the possibility for defects in the foundation area (criteria 1-13) [26];
- standard project specification of the company [27];
- according to categories [28];
- residual wood pole strength :
 - above 90 % : repair;
 - 85 – 90 % : annual monitoring;
 - below 85 % : change wood pole [30];
- decisions are made on so called "Rules of knowledge" stored in a maintenance management program. See check-list [36];
- standards in use [37];
- expertise report, feasibility study, basic design, specifications, details [40];
- only for corrosion protection according to EN ISO standards EN ISO 12944-1, ISO 4628/1, EN ISO 2409 [41];
- confidential [50];
- see attached sheets [51];
- line location (spotting) and weather conditions [54];
- inspection reports are analyzed with reference to the standards and inspections; remedial action is then recommended [56].

8.5. Latest design standard

Comments on a mix of standards :

- we try to hold the latest standard when the costs are justified [2];
- e.g. : additional constructions on supports for GSM or MW antennas : latest standard; support : original standard [3];
- based on risk assessment [4];
- some existing structures have had satisfactory duty but don't and can't meet modern standards [5];
- depends on circumstances and technical need to reach new standard and cost of achieving that [7];
- where an isolated structure needs attention or an emergency [8];
- in my company we never needed to upgrade or refurbish our transmission lines [12];
- common sense [13];
- cases involving public safety (such as high way crossings) [16];
- when there is a changing of loading cases or a problem by the material or standards [22];
- for example : body extension [24];
- only in exceptional cases (i.e. similar tower on old foundation in restricted areas). Tower to be calculated acc. to actual standard [26];
- only for refurbishment [27];
- for clearances in rural areas, for telecommunication antennas [28];
- if replacing a single tower in a line, that would be designed to the original loading criteria [30];
- like for like re-conductoring [31];
- in case of new types of lines or amendments to the national standard [32];
- if we have no problems with structure performance where the original standards were used, we leave as it is [37];
- for lines with collapsed towers : new standard; for lines without collapsed towers : old standard [40];
- if small differences [46];

- internal regulations and design are more stringent than national standards. We try to conform with internal designs first [53];
- upgrading of an existing line alone by changing only upper body and crossarms but using existing lower body and foundation [55];
- we have to use old spares in our stock since they are slow moving, and difficult to dispose of [56].

8.6. Design correlated by test

No comments.

8.7. Static analysis without test

Comments :

- less troubles since standard towers in 1967 [2];
- tests according to material standards [3];
- old structures [8];
- pole design done in house [9];
- see national standard [19];
- standard towers only [24];
- static proofs/analysis on basis of the recognized level of the technological development [26];
- method of calculation according to the national standard [30];
- wood pole : new probabilistic design has been in use since 1988 and now correlated against storm events [30];
- for new (probabilistic design) no further support tests, since original design tests [31];
- the actual test is expensive. Therefore we carry these tests to confirm accuracy of static analysis. However these cases are infrequent [35];
- if data is available, no test is done [40];
- according to foreign standards [41];
- every new tower type has been tested up to collapse [45];
- 50 year experience and over-dimensioning [46];
- we perform all the static analysis with our possibilities [48];
- not every structure is tested on test stand. We use cost effective decision on test [52];

- we use computer programs [53];
- such technology (8.6.) is not readily available here [56].

8.8. Upgrading friendly design or easy to refurbish

Comments :

- to optimize time restoration and more simple methods of work [1];
- only for (very seldom) new lines [2];
- provided the cost penalty is not too high [4];
- most difficult is leg corrosion at ground level. A stub which is replaceable through this interface has been incorporated into design (removable stub section with bolted joints at ground level) [5];
- it is a business decision to commit funding to provide upgrade potential within a new design. It depends on cost [7];
- structures designed to meet the known requirements on the day, standard configurations, geometry used with some consideration to maintenance [9];
- tangent tower can be equipped with suspension or tension insulator sets [11];
- I think that the design area are project the support without looking a future upgrade [12];
- if the required upgrade is foreseeable, we build accordingly (ex. 230 kV used initially at 120 kV) [16];
- simplify connections [18];
- consider live line work methods [18];
- transportation by helicopter [18];
- steel cross-arms for wood poles [18];
- do not design to the limit, minor future changes may become very expensive [19];
- the use of steel-lattice tower is user-friendly for upgrading and refurbishment [27];
- only if it does not increase the initial cost of the support [30];
- not appropriate for wood poles. They are easy to alter or replace [30];
- wood poles : would be beneficial [34];
- our system will not expand further. So new designs will not plan a role at all [37];
- more emphasis should be given at the design stage from the point of keeping advanced standards [48];

- must always consider life cycle cost [49];
- more capability (i.e. future larger conductors) is often utilized [53];
- the design stage should also include possibilities for attachment for live line works to reduce work on future structure modifications [55];
- the note (8.8.) above explains it all [56];
- as mentioned in the note (8.8) above [57];
- as general principle [58];
- the live line maintenance tools, attachments and procedures used to maintain lines, has to be taken into consideration at the design stage [62].

9. Experiences and solutions

9.1. Particular experiences and solutions

9.1.1. Repair / refurbishment

Comments :

- special developed anchoring systems [26];
- measures regarding reduction of buckling length, if and as required [26];
- strengthening of diagonals by replacement with high tensile steel [30];
- in case of strengthening of support leg, the replacement of the tower is preferred [30];
- tighten bolts and evaluate cause of vibration and correct [51];
- change of support top geometry to improve lightning protection [51];

9.1.2. Intermediate solution

Comments :

- provisional steel lattice towers (anchored) [2];
- mobile crane [3];
- new poles or leg extension [4];
- no [5];
- guy support [7];
- temporary wood pole section [9];
- installation of a secondary member [11];
- provisional guying of a tower [11];
- provisional structure around corner leg to replace [11];
- sometimes we use emergency supports to carry the line, other times we retired the loads to replace the support [12];
- we usually employ stays to brace support during replacement [15];
- live line work methods, temporary by-pass or conductor support, mobile generators [18];
- lowering conductors to the terrain [19];

- using emergency structures, or conductors reassuring with a crane and partial support replacement with an other crane (without conductors demounting) [20];
- stays or guys or temporary supports [22];
- switch off or temporary arrangement [24];
- special towers [25];
- temporary supports, temporary conductors respectively both being combined [26];
- sometimes we use temporary supports [27];
- use complete and partial replacement [28];
- temporary tower, temporary guyed steel mast, or temporary wood pole line for one or both circuits [30];
- the use of an emergency or fast restoration line in parallel in order to guarantee electricity transmission [36];
- we try to do a permanent fix first time [37];
- in the next future : emergency towers [40];
- conductors to ground [42];
- we have standardized towers for emergencies [44];
- we have never experienced such a case [48];
- replacement with special cranes [54];
- diversion of line at lower voltages < 132 kV [55];
- for complete replacement, we shutdown the line. For partial replacement, we replace members as per electrical safety rules [56];
- guyed lattice steel support : for complete replacement, we uplift the tower under live conditions. For partial replacement, work is done as per electrical safety rules [56];
- variable [60];
- temporary guys on tower [62].

9.1.3. Experiences or solutions with repair/refurbishment

Comments :

- bitumistic paint + dense tape at ground [5];
- continuous work requirement [6];
- repair usually associated with treating ground line corrosion [7];

- nothing [9];
- provisional reinforcement during replacement of diagonals [11];
- new foundation piles if uneven pile settlement [11]
- we find that bracing members corrode more than legs and are easily changed. If legs are badly corroded, we did install a new tower on the same foundations if the latter are OK [30];
- we do it all the time on wood poles and steel structures [37];
- we have no experience in repair / refurbishment of supports [48];
- raised towers by installing new foundations and leg extensions : moved tower body on to new legs [49];
- on very slender lattice supports which collapse due to buckling of steels near the foundation steel bolts around, the lower body and upper legs have been found to be of great help [55];
- we have recovered flooded supports from rivers and dams by cutting conductors and dismantling. We have built supports on rocky river banks in order to deviate lines [56];
- guyed lattice steel support : we uplifted one support in a dam and reinforced the base. We recovered one support when flooded in a dam by dropping it after cutting conductors [56];
- steel tubes : not much as these are fairly stable supports [56];
- replacement of main members by installation of stays to balance the power [60];
- concrete encasement of corroded main member at soil – air interface [62].

9.1.4. Precautions against vandalism

Comments :

- nothing [3, 6, 8, 9, 16, 19, 20, 24, 29, 31, 37, 46, 58];
- to avoid preformed fittings at guy bottom [1];
- to use polymeric insulators [1];
- no precautions, but the problem is raising [2];
- fencing in rural country and bollard in metropolitan area [4];
- bolts punched [5];
- not an issue [7];
- fencing [10];

- bolt brazing [10];
- different solutions available but abandoned because they can also be the subject of vandalism :
 - camera watch;
 - wall or barbed wire;
 - raising of foundation around lower legs [11];
- we inspect the support more time than normal with helicopter and by ground [12];
- for tubular poles : anchor bolts covered in concrete [16];
- secure anchor bolts [18];
- secure tower bolts up to 3 m above grade [18];
- nothing, only in front of nuclear power stations and very important line crossings. The kind is top secret [22];
- high rising concrete foundations, regular visual controls (perhaps defects may have occurred during some farming process) [26];
- normally nothing, seldom concrete protection of the leg [27];
- protect the corner legs with concrete [28];
- anti-climb guards (barbed wire) are required by the national law. Vandalism of towers is rare in our company [30];
- wood poles : anti-climbing guards (barbed wire) are legal [30];
- anti-climbing guards [34];
- wood poles : anti-climbing guards [34];
- we use special bolts (or fittings) against removing at the lower part of the support [35];
- hamper the accessibility of the tower by mounting climbing bolts not below 2,5 m above the footing [36];
- 3 m above soil, the bolts were blocked destroying the thread [40];
- till now only local robberies happened. The missing elements were replaced. Discussions (including in the mass media) with the people were done to convince them to protect the OHTL [40];
- we are not faced with this problem [41];
- polymeric insulators [50];

- notify authorities and prosecute vandals. Non ceramic insulators. Locking nuts. Removal of climbing devices [52];
- very seldom [54];
- replacement members are much less attractive by cutting them in halves and welding to full length again. Replacement bolts and nuts are welded [55];
- anti-climbing devices have welded spikes and welded bolts [56];
- bolts joining members are welded [56];
- steel tubes are very rarely vandalized [56];
- in some cases we isolate the place around the tower [60];
- utilize anti-vandalism nuts to prevent easy removal of members [62].

9.1.5. Intermediate solution in the event of vandalism (e.g. damage to a support leg)

Comments :

- only to change it [1];
- provisional towers [2];
- member replacement depending on severity of damage [4];
- varies case by case [5];
- rare event [6];
- nothing [7, 9, 29, 37, 58];
- brace leg until permanent repairs can be made [8];
- additional members to be installed and to build by-pass line; replacement of tower members [10];
- temporary guying of tower [11, 18];
- watching [11];
- we always substitute the damage part [12];
- replacement [16];
- temporary support at damaged location [18];
- no experience [19];
- strengthening of element [20];
- is different and oriented on the kind of damage [22];
- anchor [24];

- relating to the type of defect [26];
- new erecting or changing of the damaged profiles [28];
- double leg with temporary steel channel, or erect wood pole alongside and bolt to tower for small towers [30];
- wood pole may be repaired (steel jacket) [30];
- plates each side [34];
- to add a secondary member [42];
- immediate repair [46];
- temporary bracing followed by member replacement [49];
- we do not have this problem [50];
- replace / install steel members [51];
- lash wood pole onto the corner leg [52];
- the damaged profile is immediately repaired or replaced [54];
- on longer sections temporarily wooden pole support are erected while repair works can be done [55];
- it has never happened, but if so temporary supporting members should be used [56];
- guyed lattice steel support : temporary supports are erected e.g. temporary stays with anchor blocks on ground surface [56];
- steel tubes : temporary supports should be used [56];
- we use stays to equilibrate the tower [60];
- replace or refurbish damaged member at earliest convenient time [62].

9.1.6. Permanent solution for a damaged corner leg at the lower part of the support shaft

Comments :

- anchor replacement and/or stub repairs [1];
- anchoring or provisional towers [2];
- anchoring and replacement by mobile crane [3];
- replacement [5, 24, 34, 35, 39, 49, 60];
- replace or splint member [8];
- replacement like for like, splicing below ground level and making good concrete column [9];

- replacement with provisional structure around the leg or doubling of leg (cruciform) [11];
- we lock the nuts [12];
- tower leg replacement or reinforcement [18];
- exchange the profile [19];
- partial support replacement [20];
- we have already executed replacement of corner leg profiles in many cases but on the basis of static analysis only [26];
- erecting a new section of the tower [28];
- replace steelwork [30];
- replace wood pole [30];
- immediate repair [46];
- stub angle (storms) [50];
- do not have vandalism problems [51];
- replace tower. Generally, we experience leg damage on old designs built next to roads (auto damage) [52];
- replacement of the corner / leg [54];
- replacement from grillage foundation i.e. dig out damaged ones and re-cut and replace with sound [55];
- total replacement [56];
- install anti-climbing devices and/or spot weld of members at certain positions [62].

9.1.7. Permanent solution for a damaged corner leg at the higher sections of the support

Comments :

- change of damaged pieces or assembled sections of the support [1];
- see 9.1.6. [2, 3, 5, 12, 24, 30, 35, 46, 49, 56, 60];
- anchoring and replacement by mobile crane [3];
- replace or splint member [8];
- member of full tower section replacement [9];
- it does not arrive [11];
- replacement or reinforcement [18];

- no experience [19];
- partial support replacement or strengthening of corner legs [20];
- not executed up to now [26];
- erecting a new section of the support [28];
- replacement [35];
- replacement of the corner / leg [54];
- take line out of service or divert, then replace members [55];
- install anti-climbing devices and/or spot weld of members at certain positions [62].

9.2. What type of painting system is used for steel supports ?

9.2.1. On black steel

Comments :

- 1 coat red lead alkyd based – 1 primer coat zinc phosphate alkyd based – 1 cover coat with mica alkyd based [3];
- NA [4, 5, 6, 7, 19, 30, 31, 35, 42, 48, 49, 50, 52, 54, 56, 62];
- petroleum based [8];
- on austenitic steel : nothing – on normal grade steel : zinc primer, epoxy mastic top coat [9];
- coal tar : 3 or 4 layers in 3 or 4 years (180 or 240 μm) (earlier : styrenated linseed oil : 3 layers (180 μm) [11];
- see included document [16];
- using mitt and brush [17];
- sandblast or blast with calcium carbonate if required and paint with zinc rich paint [18];
- before the 70s, towers were manufactured and then painted. These towers have now to be painted every 3 or 5 years with paints made of linseed oil [20];
- 2 x priming coat; 1 x final coat [22, 23];
- 2 x primer; 1 x top coat [24];
- synthetic resin based on acryl [25];
- coating system with 3 layers [26];
- two coats of painting [27];
- use a duplex system [28];

- 2 or 3 coats of PVC-acryl [29];
- by paint brush [32];
- primer + paint, according to the laboratory certificate [40];
- 40 + 80 + 80 µm vinyl-acryl high solid paint. Hand cleaning and brushing [41];
- chloryl layer [43];
- nothing has been done on blacksteel (66 kV) [48];
- prime and paint with Keeler and Long paint. Zinc based paint [51];
- Keeler and Long 4400 series self priming paint [53];
- coat of red oxide, then bitumen on sections up to lower leg. Silver paint or zinc rich paint on upper body [55];
- 2 first protection coats and 2 finishing coats [58];
- we use the same system for galvanized towers [60].

9.2.2. On galvanized steel

Comments :

- zinc rich paint [1];
- NA [4, 5, 6, 9, 42, 48, 49, 50, 52];
- water soluble hand painted (brushed) acrylat [2];
- 1 coat primer zinc phosphate-alkyd based – 1 cover with mica alkyd based [3];
- rarely used [6];
- now using vinylester/polyester coatings (e.g. corrocoat polyester & dulux steel shield 2000) (CTE being phased out : poor performance) [7];
- petroleum based [8];
- synthetic epoxy resin (lower portion) [10];
- polyamid cured epoxy only or plus vinyl resin copolymer or acrylic resin dispersion [11];
- Keeler + Long [17];
- clean with wire brush on corroded areas and paint with a zinc rich paint [18];
- solvent borne acrylic resin [19];
- vinylic copolymer [20];

- 1 final coat [22, 23];
- 1 x primer; 1 x top coat [24];
- synthetic resin based on acryl [25];
- coating system with 2 layers [26];
- only one coat of painting [27];
- one coating of soluble paint material [28];
- 2 coats of PVC-acryl [29];
- modified alkyd (with urethanes) – 2 coat-system to specify - brush[30];
- high build vinyl paint system [31];
- by paint brush [32];
- chlorinated rubber base [34];
- factory painting system [35];
- one undercoat and one or two topcoats depending on the corrosivity of the environment [36];
- high pressure wash (with or without abrasive content) zinc rich primer and two coats of vinyl paint [37];
- we use "rust" penetrating oil-one coat [39];
- for heavy polluted areas only, according to the laboratory certificates. Note : the "rubber" paint type was not appropriate in time [40];
- 60 + 80 µm vinyl-acryl high solid paint [41];
- chloyl layer [43];
- thick layer [45];
- 2 x 70 µm coating (Epoxy) [46];
- 80 µm acryl [47];
- nothing has been done until nowadays [48];
- Keeler and Long one coat zinc based paint [51];
- no active painting program [52];
- Keeler and Long 4400 series self priming paint [53];
- anti-corrosive method [54];
- zinc or silver paint [55];

- epoxy resin [56];
- 2 first protection coats and 2 finishing coats [58];
- 5 coats [60];
- depending on protection required but normally 3 pack epoxy system [62].

9.2.3. Additional information on paint

(Material, thickness, preparation, number of coats, method of application)

Comments :

- N/A [6, 48, 50, 52];
 - brush only [1];
 - color green or gray – wet 150 µm – mechanical cleaning (brushing), if necessary sand blasting or chemical – 1 ground layer + 1 finishing layer – brushing [2];
 - resine : alkyde; Pigments : ironoxyde, zinc phosphate. Extenders : calcium-carbonate, mica – wet : 15 µm; dry 70-80 µm – cleaning with scotch brite, if necessary with brush of brass wire – 2 or 3 coats – brush [3];
 - 2x vinylester/polyester coating – 1 000 to 2 000 µm – sand blast – 2 coats brush (1st coat); spray (2nd coat) [7];
 - applied by brush [8];
 - primer : inorganic zinc silicate; finish : high build, high solids mastic – primer : 75 µm; finish : 150 µm – blast class 2 ½ – primer : 1 + finish : 1 – spray [9];
 - applied by brush [10];
 - polyamide cured epoxy :
 - polyamide cured epoxy (1 touch-up + 2-coat system or 3-coat system) (2 or 3 x 60 µm);
 - polyamide cured epoxy (1 touch-up) + vinyl resin copolymer (2-coat system) 100 µm);
 - polyamide cured epoxy (1 touch-up) + acrylic resin dispersion (2-coat system) 100 µm);
- hand + power tool cleaning;
- cleaning if galvanized surface :
- hand scraper;
 - hand clipping hammer;
 - chisel (with non woven abrasive pad and typical needle scalers);

applied by brush (or roller if large member) [11];

- Keeler + Long anodic self primary paint n° 4400 series – Con-Lux coating - tower guard 811-88 galvanized gand – Temmec coating - series 22 - galvanized gand – min 200 µm – hand scraping using wire brush or machine – 1 coat – mitt or brush [17];
- Keeler-Long 4 400 – 10 mil wet – wire brush, sand blast or blast cleaning with calcium as required – normally one coat – brush or mitt application [18];
- 100 µm – hot high pressure water washing, occasionally with a mixture of sand and water – 2 layers – spray [19];
- two layers of vynilic copolymer (primer 50 µm + finishing paint : 50 µm – brushing, scraping, descaling – applied by brush [20];
- micaceous iron are paint – 80 µm – to brush of - 1 layer – only by brush [22, 23];
- primer : alkyd/acrylbinder with non-toxic anti-corrosive pigmentations; top coat : alkyd/acrylbinder or alkyd/urethanbinder with micaceous iron oxyde – 2 layers : 160 µm – cleaning to brush – 2-coats system – brush [24];
- 2 layers (3 layers for black steel) of acryl based synthetic resin (60 µm) – cleaning by hand – applied by brush [25];
- Acrylic-resign - 40 to 80 µm - hand brushing and blasting - 2-3 layers and application by brush[26];
- environmental friendly materials (120 µm) – cleaning by hand brushing, seldom high pressure water cleaning – 1 layer (2 layers for black steel) – applied by brush in site and by spray in factory [27];
- 1 layer of soluble paint material (100 µm) – sweeping of the surface; maximum reducing thickness of galvanized steel is 10 µm – application by spray in a factory; application of bolts, gusset plates and so on by hand painting outside the factory [28];
- PVC-Acryl – 1 st layer : 40 µm; 2nd layer : 80 µm – steel brush – 2 coats – brush [29];
- copy of specification enclosed – brush [30];
- existing towers : modified vinyl primer and top coat (primer : 40 µm, top coat : 50 µm) – cleaned by hand : wire brush and scraper – applied by brush. New towers : modified vinyl Top coat (top coat : 125 µm) – prepared by mordant solution – brush [31];
- different combinations of paint can be used : epoxy polyammidic, oleophenolonic, alchidic, chlorinated rubber, polyurethanic oleourethanic, etc. – 3 or more coats depending on the type of paints used – thickness of each coat usually ≥ 40 µm – abrasion of the surface to remove rust and detached paint. Use of solvents to remove salts, grease, etc. – applied by brush [32];

- chlorinated rubber base – 100 to 120 μm – clean, wash with primer – one coat – brush [34];
- one layer of vinyl, acrylic, etc (60 to 70 μm) – cleaning by sand blast – applied by spray in factory [35];
- high build chlorinated rubber finish, pigmented with micaceous iron oxide – 60-80 μm dry (140-190 μm wet) – cutting off, scraping, brushing the old layers and cleaning with high pressure water wash – 2 or 3 coats – brush [36];
- zinc rich primer 75 μm ; vinyl undercoat and topcoat 75 & 60 μm – thickness as achieved with hand brush – wash down if no corrosion present otherwise surface preparation to SA 2,5 of AS1627.9 with 25-50 μm profile – 3 or 2 coats (3 if zinc rich primer is required) – brush [37];
- painting by brush [38];
- up to 4 layers of paint – chemical preparation, by metallic brush in maintenance – applied by brush [40];
- vinyl-acrylic – 40-90 μm – hand cleaning – 2-3 coats – by brush [41];
- 2 layers (2 x 60 μm) applied by brush [43];
- camouflage paint - light soluble agents – 60-100 μm [44];
- > 100 μm – preparation by brushing – 2 coats – paint brush [45];
- epoxyd – 2 x 70 μm – cleaning by hand brush – 2 coats – brush [46];
- 2 coats acryl – 80 μm – brush [47];
- oil alkyd/zinc dust 92 % solids by volume and 97 % solids by weight – 8 mills dry film thickness (0.008 inches) – scrape and wire brush. Clean with solvent – one coat on galvanized structures. One coat of primer and one coat of paint for painted poles – MITT application [51];
- 6-10 mils – preparation by wire brushing – one coat – mitts and brush [53];
- 1 layer of alutec – cleaning by iron brush – 1 layer is enough - applied by brush [54];
- 1) zinc rich paint for black steel. 2) Red oxyde as an anchor coat. 3) Black bitumen and red oxyde for foundation stubs – thickness is not measured but is roughly 140 μm – wire brushing and scraping up to rusty part on older structures; wire brushing only on new structures – 3 coats i.e. anchor coat and finishing coats – by brush [55];
- bitumen based – information on thickness not available, we just apply 3 coats – wire brush cleaning – 3 coats – by brush [56];

- black steel : 60 + 70 µm; galvanized steel : 80 + 80 µm – black steel : surface cleaning up to a degree between St2-St3 of national standard SIS055900167 – galvanized steel : surface cleaning to a degree between SA2 ½-SA3 of the national Standard SIS055900167 – 2 + 2 coats : 2 first protection coats + 2 finishing coats – brush [58];
- clean and degrease – five coats – by brush [60];
- first coat = > 85 % volume solids content aluminium or micaceous iron oxyde pigmented surface tolerant epoxy. Second coat = same as first coat. Third coat = twin pack aliphatic acrylic polyurethane emanel – thickness of layers : first and second layer : 80 to 100 µm; third coat 40 to 50 µm – galvanized surfaces to be cleaned prior to painting to provide a water break free surface using a solvent detergent degreaser, specially formulated by the supplier of the paint system. Water rising after cleaning is essential to remove all traces of the cleaner – three coats – brush or roller [62].

9.2.4. Other procedures in tropical climates

Comments.

None

9.2.5. Experience in tropical environment

Comments :

- epoxy resins have been used in salt splash zones in tidal areas [6];
- the systems tested that work are :
 - vinyl paints;
 - moisture cured urethanes [37];
- we have some experience with some types of paints (chesterton and carboline) Those paints have problems with the period between applications [54];
- our experience on silver paint is that the painting intervals are more frequent [55];
- yes, positive experience with epoxy resin [56];
- we made some experiences in the past, which resulted in actual process [60];
- painting on new structures is done in manufacturer workshops under controlled conditions [62];
- surface chalking of the paint due to UV light [62].

9.3. Special precautions

9.3.1. Ecological

Comments :

- ecological paintings [1];

- water soluble [2];
- most lead-free see 9.2.1. and 9.2.2. [3];
- all galvanized towers [5];
- comply with statutory requirements [9];
- in the next future only lead free paints will be used [11];
- zinc rich paint [18];
- some restrictions about using soluble components [20];
- lead-free : in case of application on zinc-coated surface ; soluble components : in case of black steel and weathering steel [26];
- we suggest to replace paints containing zinc chromates with paints containing zinc phosphates [32];
- we need resource consents that approve our methodology [37];
- ecological color [41];
- we follow the legal obligations [58].

9.3.2. Painting after galvanization

Comments :

- 10 years after erection [2];
- before first rust damages [3];
- when required due to corrosion [8];
- wait until galvanizing has deteriorated [9];
- only for red and white colors (airports) [11];
- we only paint after we have problems. We reinforced the galvanization. We only paint the metal foundation when we use, where the soil characteristics need the paint [12];
- when necessary [17];
- only painting where re-galvanization is impossible [19];
- approximately 20 years after galvanizing [20];
- or after 1-2 years [26];
- more than 10 years before corrosion appears [32];

- monitor galvanizing and coat when about 50 % loss [34];
- also in the past [36];
- no need for coating [38];
- immediately after erection in heavy polluted areas [40];
- tower structures seldom need extra coating in our grid [55];
- paint is applied after manufacturing and before erection [62];

9.3.3. **Painting before erection**

Comments :

- yes but no painting of bolts and connections [3];
- leave earth connection points with primer coat only [9];
- shunt between sections of tubular poles [16];
- sometimes before erection but with protection of the holes [27];
- no painting of bolts, sheets and gusset plates before erection [28];
- all our supports, from many years, are galvanized. Paint to new lines is applied only for environmental reasons (visual impact) when requested by regional authorities (or for warning reasons) [32];
- nothing [35];
- since 1979. First layer only in 1979-1981. After galvanizing the zinc layer is roughened by blasting in the shop. Before spraying of the first layer plastic covers are inserted in the bolt holes. The covers are removed with the erection of the tower. So conductivity is guaranteed [36];
- no need. Bolt pressure is high enough to reduce electrical resistance [46];
- only steel poles [53];
- do not use painted structures for new installations [51];
- steel tubes : earthing point cleaned before connecting [56];
- the paint is conductive [62].

9.3.4. **Cleaning surfaces**

Comments :

- manual mechanical preparation by cutting and scraping with scotch brite [3];
- water wash [8];
- mechanical clean [9];

- hand and power tool cleaning [11];
- steel brush [16];
- solvent washing if necessary [17];
- hand made unrust [24];
- all those methods are not allowed according to environmental regulations [27];
- water [29];
- wire brush / scraper [30];
- with grit (new towers) [36];
- degreasing clean according to national standard [37];
- hand cleaning with steel brushes and sand paper [41];
- brushing [46];
- wire brush if needed [53];
- iron brush [54];
- black steel : mechanical tools (pneumatic hammer of needles, brushes) [58];
- galvanized surfaces to be cleaned prior to painting to provide a water break free surface using a solvent detergent degreaser, specially formulated by the Supplier of the paint system. Water rinsing after cleaning is essential to remove all traces of the cleaner [62].

9.3.5. Covering the ground during painting or blasting

Comments :

- collect and remove waste [7];
- only when all the old paints have to be eliminated (mechanical preparation) [11];
- to control paint splatter and capture any previously applied paint during cleaning [18];
- with tilt / awning [24];
- with plastic planes [27];
- tarpaulins around the support [29];
- yes, when grit blasting [31];
- but contain run off [37];
- ingen spesielle tiltak [39];

- to capture lead paint chips [51].

9.4. Expected lifetime of coating

Comments :

- repair system [6];
- galvanisation : 50y; paint 30y [9];
- galvanization : 50 y; original paint : 20 y; new coat : 10 y [16];
- 18 years (instead of 25 years) in salt environment [27];
- proper supervision of contractors is vital [30];
- wood poles will last up to 60 years [30];
- depending upon environment [31];
- we request a 5 year guarantee for the painting [32];
- depending on dimensions and environment : 600 to 2000 m² [36];
- depending of the aggression of the area and the budget [40];
- 25 years is achievable, provided a regular coating maintenance program is followed [62].

9.5. Coating on concrete poles

Comment :

- not preventive but curative (ex. carbonation) [11].

9.6. Repair of crossarm

Other :

- Profiles in the upper horizontal bracing (horizontal formation cross arm) which have been changed immediately [26].

9.7. Support life time extension

Comments :

- welded steel plates on concrete/steel poles [4];
- welding grouted towers to legs and old towers with thrust plate fans [5];
- refurbishment of foundations mainly [6];
- pilot program : treat ground line corrosion; treat corrosion at depth with cathodic protection [7];

- wood pole ground line reinforcement and butt replacement [9];
- painting before corrosion [11];
- painting, replacing members, replacing insulators and hardware, replacing conductors and ground wires [16];
- ground line reinforcement of wood poles [18];
- repair of steel members below grade on towers [18];
- restore the Corten steel [24];
- long term experience with strict maintenance and repair program on basis of objective inspection [26];
- refurbishment of supports out of Corten-steel [28];
- replacement / reinforcement of foundations where towers are in good condition [30];
- wood poles : boron rod injection [30];
- painting only [34];
- wood poles : live line refurbishment of 110 kV wood pole lines [34];
- extensive pit corrosion of the steel under the paint coat made it necessary to exchange at about 40 % of the profiles (mostly the small sizes). Reinforcement of foot legs was carried out by adding new profiles on the old ones [36];
- adding stays to reduce bending [37];
- egen metode for forsterking – own method of reinforcement [39];
- regular corrosion protection [41];
- we have heavy experience about supports. We are operating this kind of plants from 1976 up to now [48];
- no major work is performed. Minor maintenance and painting is performed [51];
- painting in order to reduce rusting and exposure to hostile surroundings [56];
- the refurbishment of corroded members is a normal practice; members are replaced only if corrosion is beyond certain measurements even if members are diminished in strength [62].

9.8. Wood poles in tropical environment

Comments :

- eucalyptus : generally 2-4 % replacement per year with life expectation of 10 to 50 years [6];

- wooden poles have been replaced for concrete poles or steel supports [15];
- wood poles are generally used in the low voltage lines where ground clearance are not much and replacement are no big deal [55];
- treated wood poles from eucalyptus trees [56].

APPENDIX B

ENCLOSURE B.1.

AGE PROFILE OF OHL SUPPORTS

In order to compare the age profiles of the OHL supports of the different respondents, one has expressed the number of supports per age group in % of the total number of supports.

- [4] 10 % of the structures are more than 30 years old.

- [5] Age profile in years for OHL :

15-30 years : 41 %

30-40 years : 45 %

40-50 years : 14 %

- [7] Age profile in years of OHTL :

10-14 years : 1 %

15-19 years : 15 %

20-24 years : 9 %

25-29 years : 6 %

30-34 years : 21 %

35-39 years : 15 %

40-44 years : 25 %

45-49 years : 8 %

- [9] Age (years)

Age	OHTL	OHDL		
Years	Tower	Tower	Steel pole	Wood pole
5-20	48%	54%	90%	5,5%
21-30	52%	6%	10%	43%
31-40	-	22%	-	30%
41-50	-	12%	-	21%
51-60	-	6%	-	0,5%

- [11] Age distribution :
 - 150 and 220 kV : 0-75 years
 - 380 kV : 0-30 years
- [15] The oldest supports of the grid (OHL) are 45 years old.
- [18] Age profile (OHL)

	Tower	Guyed structure	Steel pole
5-30	24%	3%	66%
31-50	22%	97%	34%
31-60	21%	-	-
61-?	33%	-	-

- [19] • Oldest OHTL tower from 1952
 - Mean OHTL tower age : 25 years
- [20] Oldest supports :
 - Oldest tower : not mentioned
 - Oldest guyed support : 1959
 - Oldest steel tube : 1978
- [25] Distribution of support ages

	380 kV	220 kV	110 kV
1991-1998	1%	1%	4%
1981-1990	6%	5%	7%
1971-1980	19%	11%	17%
1961-1970	27%	16%	18%
1951-1960	26%	15%	26%
1941-1950	-	3%	4%
1931-1940	-	25%	7%
1921-1930	21%	24%	17%

- [26] Age profile of OHDL :

1990-1998 : 55%
 1970-1990 : 25%
 ? - 1970 : 20%

- [27] Mean (?) age of OHL supports :

220 – 380 kV : 30 years
 110 kV : 35 years

- [29] Distribution of support ages

	380 kV	220 kV	110 kV
1990-1995	2%	0,2%	6%
1980-1989	46%	2%	16%
1970-1979	33%	10%	17%
1960-1969	19%	46%	25%
1950-1959	0,5%	14%	27%
1940-1949	-	2%	1%
1930-1939	-	22%	3%
1920-1929	-	4%	5%

- [30] Age profile of OHDL supports :

1960- : 20%
 1940-1960 : 40%
 1933-1940 : 40%

- [32] Age profile of OHL supports :

	380 kV	150 kV
1990-2000	15%	8%
1980-1990	32%	14%
1970-1980	38%	18%
1960-1970	15%	24%
?-1960	-	36%

- [35] Approximate age profile of OHTL

	OHTL
1985-1995	10%
1975-1985	25%
1965-1975	30%
1955-1965	25%
-1955	10%

- [36] Age profile of OHL supports :

Years	21	23	28	29	31	33	34	37	39	40	45	55
%	7,5	8	31	7	2,5	5,5	3,5	7,5	8	10	5	5,5

- [40] Approximate age profile of network

0-10 years	: 1 %
10-20 years	: 15%
20-30 years	: 55%
30-40 years	: 25 %
40-50 years	: 2 %
50-60 years	: 1 %
60-70 years	: 1 %
70-80 years	: ?

- [41] Age profile of network length :

	380 kV	220 kV	110 kV
0-10 years	9%	-	8%
10-20 years	81%	7%	33%
20-30 years	10%	70%	17%
30-40 years	-	23%	19%
40-50 years	-	-	18%
50-60 years	-	-	5%

- [42] Max age (OHTL and OHDL)
 - Towers : 60 years
 - Steel tubes : 15 years
- [45] Median age (50% older/50% less old)
 - OHTL : 30 years
 - OHDL : 50 years
- [50] Mean age of OHL : 25 years
- [51] Distribution of OHL support ages (120 kV to 765 kV)
 - 1986-1995 : 2,5%
 - 1976-1985 : 8,8%
 - 1966-1975 : 36,4%
 - 1956-1965 : 17,9%
 - 1946-1955 : 20,8%
 - 1936-1945 : 0,3%
 - ?-1935 : 12,7%
- [52] Median age (at least 50% older)
 - 345 kV : 25 years
 - 138 kV : 40 years
 - 46 kV : 50 years
- [56] Distribution of support ages of OHTL
 - 20% : 3-10 years old
 - 80% older than 10 years : mean = 25 years
- [58] Age profile of OHTL supports
 - 5-20 years : 26%
 - 21-30 years : 24%
 - 31-40 years : 17%
 - 41-50 years : 24%
 - 51-60 years : 9 %

- [61] Age profile of OHL supports :

	400 kV	220 kV	110 kV
1995-1999	6 %	14 %	3 %
1985-1994	14 %	19 %	19 %
1975-1984	35 %	0 %	29 %
1965-1974	20 %	20 %	12 %
1955-1964	25 %	17 %	8 %
1945-1954	-	30 %	14 %
1935-1944	-	-	4 %
1925-1934	-	-	11 %

APPENDIX B

ENCLOSURE B.2.

INSPECTION PROCEDURES FOR OHL SUPPORTS

- [4] This company has a work code description of two pages for any support :

- poles/structures;
- crossarms/extension pieces/structural members;
- insulators.

It is conceived as a check-list with the most common defects. A choice of recommended actions is possible. Important structural defects/actions are : repair/ replacement of structural members/step bolts/anti-climbing devices footing erosion ; excessive footing movement ; guy wire corrosion/tension signs illegible/missing ; car hit ; condition of access, roads, gates and fences, possible danger for the public; etc.

- [12], [15] Those companies use one document for each type of defect. One line corresponds to one support. For each item and support the inspector must assess :

- the degree of severity of the defect ;
- the "subjective reliability" of the defective component (importance for the network).

There are 5 degrees of importance/urgency and of subjective reliability.

There are different inspection sheets for :

- local symptoms such as corrosion of elements, cracks in concrete, rupture of elements, deformation of elements, degradation of concrete, missing elements;
- global symptoms such as verticality of supports, alignment of supports, leveling of support footings, torsion of supports, tension reduction in guys, corrosion in sensitive zones, condition of earthing, condition of conductors, fittings and articulations, quantity of missing elements per support, general condition regarding indices of localized symptoms of defect.

There are also failure sheets with :

- the failure data : defective components, documentation, cause (by nature or not), origin, relationship with materials and manufacturing, consequences, cascade effect, meteorological conditions, description of the failure, solutions;

- the environmental data : structure and foundation type, terrain (physical and topographical), degree of corrosive industrial and weathering pollution.
- [17] This company proposes an one-page report for the right-of-way patrol to identify (with multiple choice possibilities) :
 - the item;
 - the defect;
 - the action.
- [18] This company provides a detailed field form (2 ½ pages) to identify the :
 - steel surface condition;
 - paint condition;
 - condition of the concrete;
 - half cell measurements, etc,
 for each of the four legs/foundations.
 For the wood poles the following three items are checked :
 - rot/cracks in the pole itself;
 - woodpecker damage (hole diameter);
 - depth of the rot in the crossarm.
 There are five ratings to categorize the importance of the severity of the damage.
- [24] This company provides a simple one-page sheet to register the most common defects in supports (deformation, corrosion, ...) and in spans (distances,...).
- [28] This company provides hand-written sheets for the determination of damages on support members (bending and cracks) and recommendations for actions as well.
- [29] This company provides inspection sheets from ground for the different components. There is a check-list with examples of irregularities (for towers : bent members, insufficient corrosion protection, nests, missing circuit panels).
- [34] This company uses a standard wood pole design in order to make live working maintenance/refurbishment tasks possible.
 The following tasks are carried out regularly and form the present core maintenance :
 - pole replacement;
 - insulation replacement;

- hardware replacement.

The following items are checked at wood poles :

- poles badly out of plumb;
- crossarms badly off level;
- lightning damage;
- danger notices and number plates in correct position;
- loose, broken or badly rusted stays.

The following items are checked at steel supports :

- rusty, bent or missing members;
- loose bolts or bolts with too little thread;
- danger notices and number plates correctly in position;
- step bolts that are not tight/straight.

- [36] This company has a comprehensive inspection procedure in three steps :
 - a periodic global inspection from the ground or from the helicopter (defects and deviations). The data are recorded in a Data Base;
 - a standard visual inspection by climbing (representative sample) after establishment of deviations. A standard inspection sheet is available. The percentage of components to inspect has to be fixed on the basis of experience;
 - a more detailed inspection after the establishment of repeated deviations (by climbing and possibly diagnostics) on the basis of sheets for detailed inspection.

The ratings vary between 0 (good) and 3 (critical).

This company has a maintenance software :

- to aim at the "unlimited" lifetime of OHL components;
- with a maintenance program as efficient as possible.

With this software the following purposes can be achieved :

- using all the information available on management and maintenance;
- using unambiguous inspection and judgment criteria;
- maintenance activities are condition based.

- [40] This company proposes to transform the tower from 220 kV double circuit into 400 kV single circuit after a detailed analysis of the corrosion and ageing degree such as:

- tower elements bent due to agricultural equipment;
 - deviations from the verticality and rotations of the guyed portal towers;
 - modifications of the tower basis geometry due to local land slide;
 - joints (angles, gusset plate and bolts) affected by corrosion;
 - missing elements due to robberies;
 - weakened guys.
- [51] This company provides a climbing patrol check list with the following points for the steel towers:
 - condition of rust on tower (4 ratings);
 - "danger" sign replaced (yes, NA);
 - tower number sign replaced (yes, NA).
 - [55] This company provides a line inspection report. It can be used for the replacement of bolts and nuts.
 - [62] This company provides some key points from the inspection and maintenance specification :
 - half-yearly routine inspection from ground to identify **defects** on the line. The general condition of the terrain and natural vegetation will prescribe the method of transport for inspection;
 - three-yearly detailed tower top inspection to evaluate the **condition** of the line components. All findings are recorded and documented in as much detail as possible (photograph, video, etc).

Maintenance cycle shall be set initially at a frequency of 3 years, or as determined by performance or breakdown history.

On occasion it is necessary to perform a detail corrosion study on a specific tower in order to verify the most appropriate or cost-effective method of refurbishment/replacement there off.

APPENDIX B

ENCLOSURE B.3.

UPGRADING / REFURBISHMENT

- [12] This company recommends tolerances for the installation of foundations, stubs (level, slope and relative horizontal position), structures (verticality, deformation of members), galvanization, dimensions of steel angles, etc.
- [16] This company describes the inspection method of the coating on the support (either painted or galvanized). There are also some recommendations for local repair. The degradation percentage can be assessed with the help of standard photographs. This company also describes methods for the corrosion evaluation of the stubs of steel supports.
- [20] By doubling the members, one can decide according to the condition of the eccentricities/assembling either to :
 - change the bucking mode;
 - distribute the axial force over the two members;
 - change the inertia moment of the original member.

By adding secondary members one can reduce the buckling length of the sustained member.

- [30] Quality assurance requirements for paintings, general specification for the primer/undercoat/top coat of a three coat alkyd system : (type, toxicity, color, specific gravity, temperature range, viscosity, drying time, wet edge time, sag resistance, applicability (brush, thickness, moisture displacement, dispersion).
- [37] This company has replacement criteria for "OHL components". They are designed to withstand anticipated maximum loads during their service life. OHL components have a finite life due to corrosion, wear, ageing and other effects.

All deteriorated components that are no longer able to satisfactorily and safely perform their intended function must be replaced before this point is reached. If a line has a limited future life the replacement criteria may be relaxed as long as the safety of the public or any legislative requirements are breached.

Wood poles are replaced when the diameter of the pole at the ground line has been reduced by deterioration to 80 % of the original design diameter (initial safety factor of 4 reduced to 2).

The use of a ground line reinforcement may be approved as an alternative to replacing the pole. The condition of the upper part is generally not a problem. Particular attention should be given to the pole condition at, and above, the guy-wire or brace attachment points.

There is a considerable variability in the rate of decay of the wood pole depending on the species of wood, environment, whether or not treated with from the inside and progress inwards or outwards, or both. External decay however is of critical importance because it is attacking the highly loaded outer pole wall. Decisions on replacing / reinforcing are based on the cross-sectional area can be established by testing, drilling, probing and hammering. This investigation is quite complex because the wood pole may rot in several locations.

Reinforced concrete poles must be replaced when they are affected by spalling or cracks remaining open causing steel reinforcing strands to corrode. The corrosion produces bursting pressures within the pole causing concrete to flake off.

The replacement or repair of **pre-stressed concrete poles** must be decided by a competent person, the only exception being that isolated minor hairline cracks should be sealed with a suitable penetrating epoxy.

Steel poles are replaced or repaired when cracking or corrosion has reduced significantly the ultimate pole strength.

Wooden crossarms are replaced when the thickness at the pole attachment point has been reduced significantly, especially when there is evidence of any rot, crack or split near where it is bolted to the pole or to the hanger points.

For **steel crossarms** the critical highly loaded areas are the pole and bracing attachment points. Excessive or unusual deflections must be reported.

The maximum reduction of tensile, compressive or bending strength is lower for leg members and crossarm horizontal members of **steel towers** than for the other steel tower members. No significant bend or bow can be permitted in leg members and crossarm horizontal members. For the other members, they may be left on the tower without remedial action when the bends are minor. Members with serious bending, sharp kinks or other distortions involving deformation of the cross sectional shape of the steel angle, must be recommended for replacement.

Compressive strength loss is most critical on the main compression loaded members i.e. all leg members, main horizontal crossarm members and other main diagonal panel bracing members loaded in compression. Other tower members are usually designed on the basis of tensile loading and can thus withstand a relatively greater loss of cross-sectional area provided that the loss does not occur adjacent to bolt holes.

The replacement of heavy loaded members should not be attempted without proper engineering investigations. Light secondary bracings which are the most susceptible to corrosion are normally lightly loaded and can be replaced without difficulty, using a correct procedure to avoid the buckling of the sustained member.

Bolts and nuts generally have a thinner galvanizing coating. Corrosion will start earlier. All rusty bolts are to be replaced prior to painting a tower.

Guy wire is to be replaced when it has developed surface rusting and before significant loss of cross-section. Ideally anchors should be load tested to full site specific working load, as confirmation of adequacy in load carrying capacity.

Generally, **replacement criteria** may be relaxed when the actual safety factor at lightly loaded sites is considerably higher.

CIGRE WG B2.08

OHL SUPPORTS

ASSESSMENT OF EXISTING OVERHEAD LINE SUPPORTS

APPENDIX C

**STATISTICAL SUMMARY OF THE ANSWERS TO THE
QUESTIONNAIRE**

RANKING OF ITEMS

June, 2003

1. Introduction

For the full explanation of the following tables, we refer to chapter 1 of the General Report on the “Assessment of Existing Overhead Line Supports”.

2. General information on the existing supports

- Table 2.1 - Type of supports per respondent with general quantities.
- Table 2.2 - Type of supports per respondent with detailed quantities.

TABLE 2.2. - QUESTIONNAIRE - ASSESSMENT OF EXISTING OHL SUPPORTS

GENERAL INFORMATION ON EXISTING SUPPORTS

TYPE OF SUPPORTS PER RESPONDENT WITH DETAILED QUANTITIES

	SUPPORTS		TOTAL (OHL)					>150 kV (OHTL)					≤150 kV (OHDL)				
	OHTL	OHDL	TOWER	GUYED ST. LATTICE	STEEL POLE	CONCR. POLE	WOOD POLE	TOWER	GUYED ST. LATTICE	STEEL POLE	CONCR. POLE	WOOD POLE	TOWER	GUYED ST. LATTICE	STEEL POLE	CONCR. POLE	WOOD POLE
1	> 1 000	-	> 1 000	X	X	X	-	> 1 000	X	X	X	-	-	-	-	-	-
2	-	> 1 000	> 1 000	-	-	-	-	-	-	-	-	-	> 1 000	-	-	-	-
3	-	2 150	2 150	-	-	-	-	-	-	-	-	-	2 150	-	-	-	-
4	> 4 200	>10 000	> 4 200	-	-	> 10 000	-	4 200	-	-	> 1 000	-	< 1 000	-	-	> 10 000	-
5	> 1 000	> 1 000	> 1 000	-	-	-	-	> 1 000	-	-	-	-	> 1 000	-	-	-	-
6	10 632	12 019	22 651	X	-	X	-	10 632	X	-	-	-	12 019	-	-	X	-
7	12 828	-	12 828	-	-	-	-	12 828	-	-	-	-	-	-	-	-	-
8	< 1 000	> 10 000	< 10 000	-	-	-	-	< 1 000	-	-	-	-	> 10 000	-	-	-	-
9	3 338	32 514	4 907	-	3 297	1 236	23 074	3 338	-	-	-	-	1 569	-	3 297	1 236	23 074
10	> 1 000	> 10 000	> 10 000	-	X	-	-	> 1 000	-	-	-	-	> 10 000	-	X	-	-
11	2 990	17 900	20 532	-	50	300	-	2 990	-	-	-	-	17 542	-	50	300	-
12	> 1 000	-	> 1 000	X	-	-	-	> 1 000	X	-	-	-	-	-	-	-	-
13	> 1 000	-	< 1 000	-	-	-	-	> 1 000	-	-	-	-	-	-	-	-	-
14	> 1 000	> 10 000	> 10 000	X	-	X	X	> 1 000	X	-	X	X	> 10 000	-	-	X	X
15	> 10 000	> 10 000	> 10 000	X	-	X	-	> 10 000	X	-	X	-	> 10 000	-	-	X	-
16	> 10 000	> 10 000	> 10 000	X	X	-	X	> 10 000	X	X	-	X	> 10 000	X	X	-	X
17	> 10 000	> 10 000	> 1 000	> 10 000	< 1 000	-	> 10 000	> 1 000	-	-	-	> 10 000	> 1 000	> 10 000	< 1 000	-	> 10 000
18	> 10 000	> 10 000	43 276	3 500	789	-	> 10 000	> 10 000	X	X	-	X	> 10 000	-	X	-	X
19	> 1 000	-	> 1 000	-	-	-	-	> 1 000	-	-	-	-	-	-	-	-	-
20	> 10 000	> 10 000	> 10 000	< 1 000	< 1 000	< 1 000	< 1 000	> 10 000	< 1 000	< 1 000	-	-	> 10 000	< 1 000	< 1 000	< 1 000	< 1 000
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22	3 079	5 440	8 519	-	-	-	-	3 079	-	-	-	-	5 440	-	-	-	-
23	> 1 000	> 1 000	X	-	X	-	-	X	-	X	-	-	X	-	X	-	-
24	-	> 1 000	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-
25	20 000	15 000	35 000	-	-	-	-	20 000	-	-	-	-	15 000	-	-	-	-
26	-	> 1 000	> 1 000	-	-	-	-	-	-	-	-	-	> 1 000	-	-	-	-
27	12 000	18 000	30 000	-	X	-	-	12 000	-	-	-	-	18 000	-	X	-	-
28	16 800	-	16 800	-	-	-	-	16 800	-	-	-	-	-	-	-	-	-
29	3 304	4 920	8 224	-	X	-	-	3 304	-	-	-	-	4 920	-	X	-	-
30	-	5 100	5 000	-	-	-	100	-	-	-	-	-	5 000	-	-	-	100
31	21 000	200	21 200	-	-	-	-	21 000	-	-	-	-	200	-	-	-	-

	SUPPORTS		TOTAL (OHL)					>150 kV (OHTL)					≤150 kV (OHDL)				
	OHTL	OHDL	TOWER	GUYED ST. LATTICE	STEEL POLE	CONCR. POLE	WOOD POLE	TOWER	GUYED ST. LATTICE	STEEL POLE	CONCR. POLE	WOOD POLE	TOWER	GUYED ST. LATTICE	STEEL POLE	CONCR. POLE	WOOD POLE
32	> 10 000	> 10 000	> 10 000	X	X	X	X	> 10 000	X	-	-	-	> 10 000	-	X	X	X
33	> 1 000	> 1 000	> 1 000	X	-	-	-	> 1 000	X	-	-	-	> 1 000	X	-	-	X
34	> 1 000	> 10 000	> 1 000	-	-	-	> 10 000	< 1 000	-	-	-	X	> 1 000	-	-	-	> 10 000
35	18 078	24 305	42 383	-	-	-	-	18 078	-	-	-	-	24 305	-	-	-	-
36	< 1 000	1 500	1 500	-	-	-	-	< 1 000	-	-	-	-	1 500	-	-	-	-
37	> 1 000	> 1 000	> 1 000	-	-	X	X	> 1 000	-	-	-	-	> 1 000	-	-	X	X
38	> 10 000	> 10 000	> 10 000	-	-	-	X	> 10 000	-	-	-	X	> 10 000	-	-	-	X
39	< 1 000	< 1 000	< 1 000	X	-	-	-	< 1 000	X	-	-	-	< 1 000	-	-	-	-
40	8 000 km	17 900km	> 10 000	X	-	X	X	> 1 000	X	-	-	-	> 10 000	-	-	X	X
41	1 855	4 568	6 423	-	-	-	-	1 855	-	-	-	-	4 568	-	-	-	-
42	> 10 000	> 10 000	> 10 000	-	< 1 000	-	-	> 10 000	-	< 1 000	-	-	> 10 000	-	< 1 000	-	-
43	> 10 000	-	> 10 000	-	-	-	-	> 10 000	-	-	-	-	-	-	-	-	-
44	> 1 000	< 1 000	> 1 000	-	> 20	> 200	-	> 1 000	-	> 20	> 200	-	< 1 000	-	X	X	-
45	> 1 000	> 1 000	> 1 000	-	-	-	-	> 1 000	-	-	-	-	> 1 000	-	-	-	-
46	5 000	5 000	10 000	-	X	X	-	5 000	-	-	-	-	X	-	X	X	-
47	> 1 000	> 10 000	> 1 000	X	800	2 000	10 000	> 1 000	X	-	-	-	-	-	800	2 000	10 000
48	> 10 000	?	> 10 000	-	-	-	-	> 10 000	-	-	-	-	?	-	-	-	-
49	> 1 000	-	> 1 000	X	-	-	-	> 1 000	X	-	-	-	-	-	-	-	-
50	30 000	120 000	37 500	X	X	X	112 500	X	X	X	X	X	X	-	X	X	X
51	5 091	7 911	8 601	-	1 765	-	2 636	3 941	-	1 126	-	24	4 660	-	639	-	2 612
52	52 700	72 600	X	-	X	-	X	X	-	X	-	-	X	-	X	-	X
53	> 1 000	> 1 000	> 1 000	-	X	-	X	> 1 000	-	X	-	-	> 1 000	-	X	-	X
54	> 10 000	< 1 000	> 10 000	-	X	X	-	> 10 000	-	X	-	-	< 1 000	-	-	X	-
55	5 000	7 000	12 000	X	-	-	X	5 000	X	-	-	-	7 000	-	-	-	X
56	> 1 000	> 1 000	> 1 000	> 1 000	> 1 000	-	-	> 1 000	> 1 000	-	-	-	> 1 000	-	> 1 000	-	-
57	-	> 1 000	-	-	-	> 1 000	-	-	-	-	-	-	-	-	> 1 000	-	-
58	> 10 000	-	> 10 000	-	-	-	-	> 10 000	-	-	-	-	-	-	-	-	-
59	-	> 1 000	> 1 000	-	-	X	-	-	-	-	-	-	> 1 000	-	-	X	-
60	-	> 1 000	> 1 000	-	-	X	-	-	-	-	-	-	> 1 000	-	-	X	-
61	> 10 000	> 10 000	-	> 10 000	-	-	> 10 000	-	> 10 000	-	-	-	-	-	-	-	> 10 000
62	49 000	-	X	X	-	-	-	X	X	-	-	-	-	-	-	-	-
TOT	53	51	59	20	22	19	19	52	19	12	6	8	48	4	20	18	20

3. Criteria for management of supports

Table 3.1. Number of answers per item

1 – 5	Priority level (1 = most important)
x	Priority level not mentioned
y	Yes
n	No
c	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

Table 3.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
S_1	Absolute number of priority level 1
S_2	Arithmetic weighted score for the priority levels
S_3	Geometric weighted score for the priority levels
$R_a, R_b,$	Corresponding ranking system
R_1, R_2, R_3	
-	No answer available, not applicable, etc.

Table 3.3. List of answers per respondent / item for OHTL

Table 3.4. List of answers per respondent / item for OHDL

Table 3.5. Total number of answers

Table 3.1. Criteria for management of supports

		OHTL											OHDL											OHL												
		1	2	3	4	5	x	y	n	c	T	-	1	2	3	4	5	x	y	n	c	T	-	1	2	3	4	5	x	y	n	c	T	-		
3.1	management criteria	symptoms of defects	10	13	10	5	4	3	0	0	0	45	8	9	13	14	6	2	1	0	0	0	45	6	19	26	24	11	6	4	0	0	0	90	14	
		sources of defects	7	14	13	2	7	1	0	0	0	44	9	6	16	14	3	6	0	0	0	0	45	6	13	30	27	5	13	1	0	0	0	89	15	
		existing condition / original strength	8	6	6	7	12	2	0	0	0	41	12	8	6	5	10	13	0	0	0	0	42	9	16	12	11	17	25	2	0	0	0	83	21	
		probability of collapse (unreliability)	20	3	4	4	12	3	0	0	0	46	7	21	2	7	1	12	1	0	0	0	44	7	41	5	11	5	24	4	0	0	0	90	14	
		network performance (availability)	5	12	11	7	8	1	0	0	0	44	9	6	12	10	7	10	0	0	0	0	45	6	11	24	21	14	18	1	0	0	0	89	15	
		available budget	3	7	11	6	14	1	0	0	0	42	11	4	7	10	7	12	0	0	0	0	40	11	7	14	21	13	26	1	0	0	0	82	22	
3.2	what do you perform?	maintenance routine conservation	0	0	0	0	0	0	43	9	0	52	1	0	0	0	0	0	0	45	5	0	50	1	0	0	0	0	0	0	88	14	0	102	2	
		occasional local repair	0	0	0	0	0	0	48	1	0	49	4	0	0	0	0	0	0	46	1	0	47	4	0	0	0	0	0	0	94	2	0	96	8	
		life extension	0	0	0	0	0	0	38	12	0	50	3	0	0	0	0	0	0	41	7	0	48	3	0	0	0	0	0	0	79	19	0	98	6	
		refurbishment	0	0	0	0	0	0	39	10	0	49	4	0	0	0	0	0	0	38	8	0	46	5	0	0	0	0	0	0	77	18	0	95	9	
		upgrading	0	0	0	0	0	0	32	18	0	50	3	0	0	0	0	0	0	37	11	0	48	3	0	0	0	0	0	0	69	29	0	98	6	
3.3	reason for maintenance	minor corrosion	10	9	10	6	13	2	0	0	0	50	3	11	7	12	5	10	2	0	0	0	47	4	21	16	22	11	23	4	0	0	0	97	7	
		paint deterioration	6	7	8	9	10	2	0	0	0	42	11	6	8	10	9	8	2	0	0	0	43	8	12	15	18	18	18	4	0	0	0	85	19	
		vegetation	16	9	7	8	6	1	0	0	0	47	6	17	11	7	7	4	0	0	0	0	46	5	33	20	14	15	10	1	0	0	0	93	11	
		deformation of elements	5	11	9	4	14	1	0	0	0	44	9	4	11	7	5	15	0	0	0	0	42	9	9	22	16	9	29	1	0	0	0	86	18	
		loose bolts	3	9	4	8	16	0	0	0	0	40	13	3	7	3	8	18	1	0	0	0	40	11	6	16	7	16	34	1	0	0	0	80	24	
		other	7	2	1	0	0	0	0	0	0	10	43	8	0	2	0	0	0	0	0	0	10	41	15	2	3	0	0	0	0	0	0	20	84	
		comment	0	0	0	0	0	0	0	13	13	40	0	0	0	0	0	0	0	0	0	14	14	37	0	0	0	0	0	0	0	0	0	27	77	
			7	6	7	4	13	2	0	0	0	39	14	9	5	8	6	11	1	0	0	0	40	11	16	11	15	10	24	3	0	0	0	79	25	
3.4	reason for refurbishment and life extension	extensive corrosion by industrial atmos	15	3	4	6	12	5	0	0	0	45	8	14	4	5	7	10	3	0	0	0	43	8	29	7	9	13	22	8	0	0	0	88	16	
		extensive corros. by norm. weathering	4	2	2	1	1	3	0	0	0	13	40	5	2	3	1	0	2	0	0	0	13	38	9	4	5	2	1	5	0	0	0	26	78	
		other	0	0	0	0	0	0	0	15	15	38	0	0	0	0	0	0	0	0	0	15	15	36	0	0	0	0	0	0	0	0	0	30	74	
		comment	2	6	4	6	17	1	0	0	0	36	17	2	7	4	10	16	1	0	0	0	40	11	4	13	8	16	33	2	0	0	0	76	28	
		deformation of crossarms	2	4	1	4	19	2	0	0	0	32	21	2	4	2	6	20	2	0	0	0	36	15	4	8	3	10	39	4	0	0	0	68	36	
		deformation of the support shaft	5	1	4	6	20	1	0	0	0	37	16	5	1	5	3	20	1	0	0	0	35	16	10	2	9	9	40	2	0	0	0	72	32	
		deformation by vandalism	1	0	2	2	26	0	0	0	0	31	22	1	0	4	2	22	0	0	0	0	29	22	2	0	6	4	48	0	0	0	0	60	44	
		global support deformation	1	5	0	16	15	0	0	0	0	37	16	1	7	1	15	10	0	0	0	0	34	17	2	12	1	31	25	0	0	0	0	71	33	
		support inclination	1	4	3	10	16	0	0	0	0	34	19	0	5	4	8	17	0	0	0	0	34	17	1	9	7	18	33	0	0	0	0	68	36	
		deformation by uneven settlements	5	3	11	5	14	0	0	0	0	38	15	4	4	7	8	12	1	0	0	0	36	15	9	7	18	13	26	1	0	0	0	74	30	
		connection to foundations (local corros)	2	2	0	0	0	1	0	0	0	5	48	1	1	1	0	0	1	0	0	0	4	47	3	3	1	0	0	2	0	0	0	9	95	
other	0	0	0	0	0	0	0	0	7	7	46	0	0	0	0	0	0	0	0	0	6	6	45	0	0	0	0	0	0	0	0	0	13	91		
comment	10	8	4	8	8	1	0	0	0	39	14	10	15	7	6	4	1	0	0	0	43	8	20	23	11	14	12	2	0	0	0	82	22			
3.5	reason for upgrading	higher ground clearances	1	1	5	1	20	0	0	0	0	28	25	2	1	7	3	17	0	0	0	0	30	21	3	2	12	4	37	0	0	0	0	58	46	
		larger internal electrical clearances	1	0	2	2	25	1	0	0	0	31	22	1	0	2	2	24	0	0	0	0	29	22	2	0	4	4	49	1	0	0	0	60	44	
		electromagnetic impact demands	5	4	7	6	10	1	0	0	0	33	20	2	6	6	7	9	0	0	0	0	30	21	7	10	13	13	19	1	0	0	0	63	41	
		installation of spec. equipment/OPGW	5	9	7	3	11	0	0	0	0	35	18	9	10	8	4	8	0	0	0	0	39	12	14	19	15	7	19	0	0	0	0	74	30	
		conductor change (higher tpt capacity)	8	4	6	4	11	2	0	0	0	35	18	7	4	7	6	10	1	0	0	0	35	16	15	8	13	10	21	3	0	0	0	70	34	
		higher operating temperature	7	1	5	3	13	0	0	0	0	29	24	4	2	5	6	14	0	0	0	0	31	20	11	3	10	9	27	0	0	0	0	60	44	
		higher voltage level	5	3	1	7	14	0	0	0	0	30	23	4	3	2	8	13	0	0	0	0	30	21	9	6	3	15	27	0	0	0	0	60	44	
		higher meteorological loads	0	0	1	0	1	0	0	0	0	2	51	1	0	1	0	0	0	0	0	0	2	49	1	0	2	0	1	0	0	0	0	4	100	
		other	0	0	0	0	0	0	0	0	9	9	44	0	0	0	0	0	0	0	0	0	7	7	44	0	0	0	0	0	0	0	0	0	16	88
		comment	0	0	0	0	0	0	0	0	9	9	44	0	0	0	0	0	0	0	0	0	7	7	44	0	0	0	0	0	0	0	0	0	16	88

Table 3.2. Criteria for management of supports (OHL)

		OHTL										OHDL										OHL												
		Sa	Sb	S1	S2	S3	Ra	Rb	R1	R2	R3	Sa	Sb	S1	S2	S3	Ra	Rb	R1	R2	R3	Sa	Sb	S1	S2	S3	Ra	Rb	R1	R2	R3			
3.1	management criteria	symptoms of defects			10	58	39			2	1	2			9	61	39			2	1	2			19	59	39			2	1	2		
		sources of defects			7	54	34			4	3	3			6	58	35			4	3	3			13	56	35			4	3	3		
		existing condition / original strength			8	43	27			3	5	5			8	44	27			3	5	5			16	43	27			3	5	5		
		probability of collapse (unreliability)			20	57	46			1	2	1			21	59	48			1	2	1			41	58	47			1	2	1		
		network performance (availability)			5	49	28			5	4	4			6	52	31			4	4	4			11	50	30			5	4	4		
		available budget			3	39	20			6	6	6			4	41	22			6	6	6			7	40	21			6	6	6		
3.2	What do you perform?	maintenance routine conservation	0.81	0.83				2	2				0.88	0.90				2	2				0.85	0.86				2	2					
		occasional local repair	0.91	0.98				1	1				0.90	0.98				1	1				0.90	0.98				1	1					
		life extension	0.72	0.76				4	4				0.80	0.85				3	3				0.76	0.81				3	4					
		refurbishment	0.74	0.80				3	3				0.75	0.83				4	4				0.74	0.81				4	3					
		upgrading	0.60	0.64				5	5				0.73	0.77				5	5				0.66	0.70				5	5					
3.3	reason for maintenance	minor corrosion			10	55	35			2	2	2			11	56	37			2	2	2			21	56	36			2	2	2		
		paint deterioration			6	43	25			3	4	4			6	48	28			3	3	3			12	46	27			3	3	3		
		vegetation			16	61	45			1	1	1			17	66	49			1	1	1			33	63	47			1	1	1		
		deformation of elements			5	45	27			4	3	3			4	43	25			4	4	4			9	44	26			4	4	4		
		loose bolts			3	36	19			5	5	5			3	35	18			5	5	5			6	35	19			5	5	5		
		other																																
		comment																																
		3.4	reason for refurbishment and life extension	extensive corrosion by industrial atmos.			7	40	25			2	2	2			9	45	29			2	2	2			16	42	27			2	2	2
				extensive corrosion by norm. weathering			15	51	38			1	1	1			14	52	38			1	1	1			29	52	38			1	1	1
				other																														
comment																																		
deformation of crossarms					2	29	15			5	4	5			2	35	17			5	3	4			4	32	16			5	4	5		
deformation of the support shaft					2	23	12			5	8	6			2	27	13			5	7	7			4	25	12			5	8	6		
deformation by vandalism					5	28	16			3	5	4			5	28	16			3	6	5			10	28	16			3	5	4		
global support deformation					1	15	6			7	9	9			1	17	6			7	9	9			2	16	6			7	9	9		
support inclination					1	27	11			7	6	7			1	30	13			7	5	6			2	28	12			7	5	7		
deformation by uneven settlements					1	25	10			7	7	8			0	25	10			9	8	8			1	25	10			9	7	8		
3.5	reason for upgrading	connection to foundations (local corros.)			5	35	20			3	3	3			4	34	18			4	4	3			9	35	19			4	3	3		
		other																																
		comment																																
		higher ground clearances			10	45	31			1	1	1			10	59	40			1	1	1			20	52	35			1	1	1		
		larger internal electrical clearances			1	17	7			7	7	7			2	23	11			6	7	7			3	20	9			7	7	7		
		electromagnetic impact demands			1	16	6			7	8	8			1	15	6			8	8	8			2	16	6			8	8	8		
		installation of special equipment/OPGW			5	33	19			4	4	4			2	29	15			6	4	4			7	31	17			6	4	4		
		conductor change (higher tpt capacity)			5	37	23			4	2	3			9	49	33			2	2	2			14	43	28			3	2	2		
		higher operating temperature			8	37	24			2	3	2			7	38	24			3	3	3			15	37	24			2	3	3		
		higher voltage level			7	28	18			3	5	5			4	27	15			4	5	5			11	27	17			4	5	5		
higher meteorological loads			5	26	15			4	6	6			4	26	15			4	6	6			9	26	15			5	6	6				
other																							0											
comment																																		

Table 3.5. Criteria for management of supports

	<u>OHTL</u>					<u>OHDL</u>				
	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>
1	3.53	0.20	3.00	6.00	187	3.67	1.00	4.00	6.00	187
2	3.17	0.00	3.00	6.00	168	3.55	1.00	4.00	6.00	181
3	3.21	0.20	3.00	5.80	170	3.73	1.00	4.00	6.00	190
4	3.02	1.00	2.00	6.00	160	3.45	1.00	3.00	6.00	176
5	7.21	1.00	6.00	14.00	382	6.80	1.00	6.00	14.00	347
x	0.70	0.00	0.00	2.80	37	0.41	0.00	0.00	0.00	21
y	3.77	2.00	4.00	5.00	200	4.06	2.00	4.00	5.00	207
n	0.94	0.00	1.00	2.80	50	0.63	0.00	0.00	2.00	32
c	25.55	4.50	22.50	49.30	44	26.29	7.10	25.50	45.90	42
T					1398					1383
-	14.62	6.00	13.00	27.00	775	13.88	6.00	11.00	25.00	708

4. Inspection philosophies

Table 4.1. Number of answers per item

p	Partly yes
y	Yes (or numerical value)
n	No
c	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable etc.

Table 4.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
Mean	Mean of the array of numerical values
10 %	First decile of the array of numerical values
50 %	Median of the array of numerical values
90 %	Ninth decile of the array of numerical values

Table 4.3. List of answers per respondent / item for OHTL

Table 4.4. List of answers per respondent / item for OHDL

Table 4.5. Total number of answers

Table 4.1. Inspection philosophies

		OHTL					OHDL					OHL									
		p	y	n	c	T	-	p	y	n	c	T	-	p	y	n	c	T	-		
4.1	regular inspections	do you inspect your supports regularly?	0	53	0	0	53	0	0	51	0	0	51	0	0	104	0	0	104	0	
		visual inspections for the general lines	0	51	2	0	53	0	0	49	2	0	51	0	0	100	4	0	104	0	
		period of inspection	from car	0	0	0	0	0	42	0	0	0	0	0	38	0	0	0	0	0	80
			from ground	0	0	0	0	0	13	0	0	0	0	0	14	0	0	0	0	0	27
			by climbing	0	0	0	0	0	20	0	0	0	0	0	19	0	0	0	0	0	39
			from helicopter	0	0	0	0	0	14	0	0	0	0	0	21	0	0	0	0	0	35
			other	0	0	0	0	0	50	0	0	0	0	0	49	0	0	0	0	0	99
		sampling rate	from car	0	0	0	0	0	43	0	0	0	0	0	38	0	0	0	0	0	81
			from ground	0	0	0	0	0	16	0	0	0	0	0	15	0	0	0	0	0	31
			by climbing	0	0	0	0	0	21	0	0	0	0	0	20	0	0	0	0	0	41
			from helicopter	0	0	0	0	0	17	0	0	0	0	0	22	0	0	0	0	0	39
			other	0	0	0	0	0	50	0	0	0	0	0	49	0	0	0	0	0	99
		comment	0	0	0	10	10	43	0	0	0	10	10	41	0	0	0	20	20	84	
		visual inspections for the strategic lines	0	45	8	0	53	0	0	41	7	0	48	3	0	86	15	0	101	3	
		period of inspection	from car	0	0	0	0	0	46	0	0	0	0	0	41	0	0	0	0	0	87
			from ground	0	0	0	0	0	20	0	0	0	0	0	21	0	0	0	0	0	41
			by climbing	0	0	0	0	0	26	0	0	0	0	0	25	0	0	0	0	0	51
			from helicopter	0	0	0	0	0	19	0	0	0	0	0	25	0	0	0	0	0	44
			other	0	0	0	0	0	50	0	0	0	0	0	48	0	0	0	0	0	98
		sampling rate	from car	0	0	0	0	0	45	0	0	0	0	0	40	0	0	0	0	0	85
from ground	0		0	0	0	0	21	0	0	0	0	0	20	0	0	0	0	0	41		
by climbing	0		0	0	0	0	26	0	0	0	0	0	25	0	0	0	0	0	51		
from helicopter	0		0	0	0	0	20	0	0	0	0	0	26	0	0	0	0	0	46		
other	0		0	0	0	0	49	0	0	0	0	0	49	0	0	0	0	0	98		
comment	0	0	0	9	9	44	0	0	0	9	9	42	0	0	0	18	18	86			
more detailed regular inspections	0	19	33	0	52	1	0	19	31	0	50	1	0	38	64	0	102	2			
comment	0	0	0	15	15	38	0	0	0	15	15	36	0	0	0	30	30	74			
4.2	only occasional inspections	0	8	41	0	49	4	0	9	40	0	49	2	0	17	81	0	98	6		
4.3	min. requirements	min qualifications for inspectors/linesmen	0	45	8	0	53	0	0	42	9	0	51	0	0	87	17	0	104	0	
		comment	0	0	0	38	38	15	0	0	0	33	33	18	0	0	0	71	71	33	
		established training programme	0	26	27	0	53	0	0	23	28	0	51	0	0	49	55	0	104	0	
		comment	0	0	0	8	8	45	0	0	0	7	7	44	0	0	0	15	15	89	
4.4	% of maintenance+refurbishment budget	0	0	0	0	0	19	0	0	0	0	0	15	0	0	0	0	0	34		
comment	0	0	0	9	9	44	0	0	0	11	11	40	0	0	0	20	20	84			
4.5	maint.+refurbish. organised by own personnel	9	35	9	0	53	0	10	31	10	0	51	0	19	66	19	0	104	0		
comment	0	0	0	26	26	27	0	0	0	27	27	24	0	0	0	53	53	51			
4.6	maint.+refurbish. performed by other companies	12	26	15	0	53	0	10	26	15	0	51	0	22	52	30	0	104	0		
comment	0	0	0	31	31	22	0	0	0	26	26	25	0	0	0	57	57	47			
4.7	permanent condition monitoring	0	7	43	0	50	3	0	7	42	0	49	2	0	14	85	0	99	5		
comment	0	0	0	8	8	45	0	0	0	6	6	45	0	0	0	14	14	90			

Table 4.2. Inspections philosophies (OHL)

		<u>OHTL</u>				<u>OHDL</u>				<u>OHL</u>										
		Sa	Sb	Mean	10%	50%	90%	Sa	Sb	Mean	10%	50%	90%	Sa	Sb	Mean	10%	50%	90%	
regular inspections	do you inspect your supports regularly?	1.00	1.00					1.00	1.00					1.00	1.00					
	visual inspections for the general lines	0.96	0.96					0.96	0.96					0.96	0.96					
	period of inspection	from car			1.4	0.4	1.0	3.0			1.4	0.5	1.0	2.8			1.4	0.5	1.0	2.9
		from ground			1.6	0.5	1.0	3.2			1.3	0.5	1.0	3.0			1.4	0.5	1.0	3.1
		by climbing			4.5	1.0	3.0	10.0			4.0	1.0	2.5	10.0			4.2	1.0	2.8	10.0
		from helicopter			1.7	0.5	1.0	4.0			1.3	0.5	1.0	3.1			1.5	0.5	1.0	3.6
		other			14.4	0.8	3.0	32.6			20.5	4.9	20.5	36.1			16.9	2.9	11.8	34.4
	sampling rate	from car			61	29	48	100			55	20	50	100			57	25	49	100
		from ground			89	50	100	100			86	50	100	100			87	50	100	100
		by climbing			53	5	40	100			54	10	25	100			53	8	33	100
		from helicopter			93	80	100	100			94	80	100	100			94	80	100	100
		other			50	16	40	88			30	14	30	46			42	15	35	67
	comment																			
	visual inspections for the strategic lines	0.85	0.85					0.80	0.85					0.83	0.85					
	period of inspection	from car			0.9	0.3	1.0	1.4			0.8	0.5	0.5	1.1			0.8	0.4	0.8	1.3
from ground				1.4	0.5	1.0	3.0			1.1	0.5	1.0	2.1			1.3	0.5	1.0	2.6	
by climbing				3.2	0.5	1.0	6.0			2.8	0.5	1.0	5.0			3.0	0.5	1.0	5.5	
from helicopter				1.6	0.5	1.0	4.0			1.3	0.5	1.0	3.5			1.5	0.5	1.0	3.8	
other				14.4	0.8	3.0	32.6			20.3	4.8	20.0	36.0			17.4	2.8	11.5	34.3	
sampling rate	from car			73	44	80	100			62	10	50	100			66	27	65	100	
	from ground			95	100	100	100			86	30	100	100			90	65	100	100	
	by climbing			59	5	60	100			61	8	75	100			60	6	68	100	
	from helicopter			96	100	100	100			95	100	100	100			95	100	100	100	
	other			50	16	40	88			30	14	30	46			42	15	35	67	
comment																				
more detailed regular inspections	0.36	0.37					0.37	0.38					0.37	0.37						
comment																				
4.2	only occasional inspections	0.15	0.16					0.18	0.18					0.16	0.17					
4.3	min. req.	0.85	0.85					0.82	0.82					0.84	0.84					
	comment																			
4.3	established training programme	0.49	0.49					0.45	0.45					0.47	0.47					
	comment																			
4.4	% of maintenance+refurbishment budget			27.2	3.0	15.0	70.5			28.3	4.0	20.0	52.5			27.8	3.5	17.5	61.5	
comment																				
4.5	maint. +refurbish. organised by own	0.83	0.83					0.80	0.80					0.82	0.82					
comment																				
4.6	maint. +refurbish. performed by other comp.	0.72	0.72					0.71	0.71					0.71	0.71					
comment																				
4.7	permanent condition monitoring	0.13	0.14					0.14	0.14					0.13	0.14					
comment																				

Table 4.5. Inspection philosophies

	<u>OHTL</u>					<u>OHDL</u>				
	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>
p	0.40	0.00	0.00	2.00	21	0.39	0.00	0.00	2.00	20
y	5.94	4.00	6.00	8.00	315	5.84	4.00	6.00	8.00	298
n	3.51	2.00	4.00	5.00	186	3.61	2.00	4.00	5.00	184
c	2.98	0.20	3.00	5.00	158	2.92	0.00	3.00	6.00	149
T					680					631
-	19.00	12.20	19.00	24.80	1007	19.39	12.00	19.00	26.00	989

5. Type and causes of defects

Table 5.1. Number of answers per item

1 – 5	Priority level (1 = most important)
X	Priority level not mentioned
Y	Yes (or numerical value)
N	No
C	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

Table 5.2. Ranking of items

S _a	Score of ratio : yes / number of respondents
S _b	Score of ratio : yes / (yes + no)
S ₁	Absolute number of priority level 1
S ₂	Arithmetic weighted score for the priority levels
S ₃	Geometric weighted score for the priority levels
10 %	First decile of the array of numerical values
50 %	Median of the array of numerical values
90 %	Ninth decile of the array of numerical values

Table 5.3. List of answers per respondent / item for OHTL

Table 5.4. List of answers per respondent / item for OHDL

Table 5.5. Total number of answers

Table 5.1. Type and causes of defects

		OHTL													OHDL													OHL												
		1	2	3	4	5	x	y	n	c	T	-	1	2	3	4	5	x	y	n	c	T	-	1	2	3	4	5	x	y	n	c	T	-						
5.1	typical identified faults	faults of protection painting	9	6	7	6	13	2	0	0	0	43	10	10	7	7	6	11	1	0	0	0	42	9	19	13	14	12	24	3	0	0	0	85	19					
		faults of corrosion of structural steel	8	7	9	15	5	3	0	0	0	47	6	8	8	10	14	3	1	0	0	0	44	7	16	15	19	29	8	4	0	0	0	91	13					
		faults of stays, guys, connections	2	2	5	5	12	1	0	0	0	27	26	2	4	8	6	10	1	0	0	0	31	20	4	6	13	11	22	2	0	0	0	58	46					
		lose/missing bolts/nuts/washers	4	3	12	7	15	1	0	0	0	42	11	4	3	13	6	16	1	0	0	0	43	8	8	6	25	13	31	2	0	0	0	85	19					
		default in welds	1	0	1	3	23	0	0	0	0	28	25	1	0	1	4	23	0	0	0	0	29	22	2	0	2	7	46	0	0	0	0	57	47					
		faults at the connection to the foundation	1	4	7	9	19	1	0	0	0	41	12	1	6	6	10	15	1	0	0	0	39	12	2	10	13	19	34	2	0	0	0	80	24					
		deformation of elem. of the main supports	2	2	2	15	19	1	0	0	0	41	12	2	4	3	15	17	0	0	0	0	41	10	4	6	5	30	36	1	0	0	0	82	22					
		deformation in the crossarms	0	3	5	7	20	1	0	0	0	36	17	2	2	4	8	22	1	0	0	0	39	12	2	5	9	15	42	2	0	0	0	75	29					
		reduced tension in stay wires	3	2	3	6	8	0	0	0	0	22	31	2	2	3	6	9	0	0	0	0	22	29	5	4	6	12	17	0	0	0	0	44	60					
		wood deterioration	1	0	1	1	9	0	0	0	0	12	41	7	0	2	2	10	1	0	0	0	22	29	8	0	3	3	19	1	0	0	0	34	70					
		concrete deterioration	1	4	3	9	8	2	0	0	0	27	26	2	5	9	7	10	2	0	0	0	35	16	3	9	12	16	18	4	0	0	0	62	42					
		faults due to corrosion on small elements	1	5	1	4	9	1	0	0	0	21	32	1	4	2	5	8	0	0	0	0	20	31	2	9	3	9	17	1	0	0	0	41	63					
		other	1	0	0	0	1	1	0	0	0	3	50	1	1	0	1	1	1	0	0	0	5	46	2	1	0	1	2	2	0	0	0	8	96					
comment	0	0	0	0	0	0	0	0	8	8	45	0	0	0	0	0	0	0	0	7	44	0	0	0	0	0	0	0	0	0	15	15	89							
percentage of supports without defect	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	19						
comment	0	0	0	0	0	0	0	0	11	11	42	0	0	0	0	0	0	0	0	12	12	39	0	0	0	0	0	0	0	0	23	23	81							
5.2	reason of collapse	due to cascade	1	3	4	3	17	3	0	0	0	31	22	3	2	3	3	16	2	0	0	0	29	22	4	5	7	6	33	5	0	0	0	60	44					
		due to wind loading	12	1	5	5	11	5	0	0	0	39	14	9	3	3	5	12	5	0	0	0	37	14	21	4	8	10	23	10	0	0	0	76	28					
		due to ice loading	3	1	4	2	17	2	0	0	0	29	24	2	3	3	4	14	3	0	0	0	29	22	5	4	7	6	31	5	0	0	0	58	46					
		due to wind and ice loading	6	1	2	3	14	2	0	0	0	28	25	6	2	2	4	13	4	0	0	0	31	20	12	3	4	7	27	6	0	0	0	59	45					
		due to conductor breakage	1	0	1	9	19	1	0	0	0	31	22	1	1	1	9	16	1	0	0	0	29	22	2	1	2	18	35	2	0	0	0	60	44					
		due to material defects	4	1	2	2	19	0	0	0	0	28	25	3	1	3	3	15	0	0	0	0	25	26	7	2	5	5	34	0	0	0	0	53	51					
		due to erection/construction faults	1	2	3	2	20	0	0	0	0	28	25	1	2	3	3	17	0	0	0	0	26	25	2	4	6	5	37	0	0	0	0	54	50					
		due to vandalism	3	2	2	6	17	3	0	0	0	33	20	3	1	4	4	16	3	0	0	0	31	20	6	3	6	10	33	6	0	0	0	64	40					
		due to delayed preventive maintenance	1	0	2	3	18	0	0	0	0	24	29	1	1	1	4	18	0	0	0	0	25	26	2	1	3	7	36	0	0	0	0	49	55					
		due to fatigue (conductor vibration)	0	1	3	5	17	1	0	0	0	27	26	1	1	2	5	16	1	0	0	0	26	25	1	2	5	10	33	2	0	0	0	53	51					
		other	1	1	3	4	3	2	0	0	0	14	39	3	0	3	3	2	2	0	0	0	13	38	4	1	6	7	5	4	0	0	0	27	77					
		comment	0	0	0	0	0	0	0	0	15	15	38	0	0	0	0	0	0	0	0	15	15	36	0	0	0	0	0	0	0	0	30	30	74					
		5.3	type/cause of corrosion	normal weathering	18	3	8	10	4	5	0	0	0	48	5	19	2	8	9	4	6	0	0	48	3	37	5	16	19	8	11	0	0	0	96	8				
industrial pollution	5			8	5	10	8	2	0	0	0	38	15	5	8	10	7	7	4	0	0	0	41	10	10	16	15	17	15	6	0	0	0	79	25					
maritime site (salt corrosion)	4			4	8	6	7	4	0	0	0	33	20	4	3	5	8	8	4	0	0	0	32	19	8	7	13	14	15	8	0	0	0	65	39					
high humidity in tropical zones	0			0	2	0	13	1	0	0	0	16	37	0	0	3	1	13	1	0	0	0	18	33	0	0	5	1	26	2	0	0	0	34	70					
in temperate zones	1			0	1	2	17	0	0	0	0	21	32	1	0	2	1	18	1	0	0	0	23	28	2	0	3	3	35	1	0	0	0	44	60					
gap corrosion (pack rust)	2			1	1	3	18	0	0	0	0	25	28	1	2	3	3	18	1	0	0	0	28	23	3	3	4	6	36	1	0	0	0	53	51					
inter-crystalline corrosion of material	1			1	1	3	15	0	0	0	0	21	32	0	1	1	2	19	0	0	0	0	23	28	1	2	2	5	34	0	0	0	0	44	60					
heavy vegetation growth in trop. zones	0			1	2	1	12	0	0	0	0	16	37	0	1	0	2	12	0	0	0	0	15	36	0	2	2	3	24	0	0	0	0	31	73					
in temp. zones	2			0	0	3	15	0	0	0	0	20	33	2	2	0	2	16	1	0	0	0	23	28	4	2	0	5	31	1	0	0	0	43	61					
other	3			1	1	1	0	3	0	0	0	9	44	1	1	0	1	0	3	0	0	0	6	45	4	2	1	2	0	6	0	0	0	15	89					
comment	0			0	0	0	0	0	0	0	10	10	43	0	0	0	0	0	0	0	0	8	8	43	0	0	0	0	0	0	0	0	18	18	86					
5.4	reason for corrosion problems			no galvanizing	5	1	2	2	19	3	0	0	0	32	21	5	0	2	3	17	3	0	0	30	21	10	1	4	5	36	6	0	0	0	62	42				
				no painting	0	3	4	4	15	0	0	0	0	26	27	1	4	4	4	14	1	0	0	0	28	23	1	7	8	8	29	1	0	0	0	54	50			
		no re-painting	2	2	8	4	11	0	0	0	0	27	26	4	4	7	3	9	1	0	0	0	28	23	6	6	15	7	20	1	0	0	0	55	49					
		inadequate detailing	0	1	2	4	15	1	0	0	0	23	30	1	0	2	5	15	0	0	0	0	23	28	1	1	4	9	30	1	0	0	0	46	58					
		poor erection	0	2	0	2	19	0	0	0	0	23	30	0	2	0	3	17	0	0	0	0	22	29	0	4	0	5	36	0	0	0	0	45	59					
		weathering steel (Corten steel)	3	2	1	1	16	0	0	0	0	23	30	2	3	1	3	14	0	0	0	0	23	28	5	5	2	4	30	0	0	0	0	46	58					
		low or delayed maintenance	2	3	3	7	17	0	0	0	0	32	21	2	2	4	9	15	1	0	0	0	33	18	4	5	7	16	32	1	0	0	0	65	39					
		other	6	0	1	0	1	4	0	0	0	12	41	4	0	0	2	0	4	0	0	0	10	41	10	0	1	2	1	8	0	0	0	22	82					
		comment	0	0	0	0	0	0	0	0	14	14	39	0	0	0	0	0	0	0	0	11	11	40	0	0	0	0	0	0	0	0	25	25	79					
		5.5	subject of corrosion problem	the complete support	7	2	6	4	11	3	0	0	0	33	20	7	1	8	2	12	3	0	0	33	18	14	3	14	6	23	6	0	0	0	66	38				
				mainly the support footing area	11	4	7	5	8	1	0	0	0	36	17	8	4	5	8	7	1	0	0	0	33	18	19	8	12	13	15	2	0	0	0	69	35			
				connection of bars	5	1	7	7	7	1	0	0	0	28	25	5	1	5	5	8	2	0	0	0	26	25	10	2	12	12	15	3	0	0	0	54	50			
				gusset plates	2	5	7	2	13	1	0	0	0	30	23	2	1	6	2	13	2	0	0	0	26	25	4	6	13	4	26	3	0	0	0	56	48			
size (corners of gusset plates)	4			2	3	3	13	0	0	0	0	25	28	2	1	3																								

Table 5.2. Type and causes of defects (OHL)

		OHTL										OHDL										OHL													
		Sa	Sb	S1	S2	S3	Mean	10%	50%	90%	R1	R2	R3	Sa	Sb	S1	S2	S3	Mean	10%	50%	90%	R1	R2	R3	Sa	Sb	S1	S2	S3	Mean	10%	50%	90%	R1	R2	R3
5.1	typical identified faults	faults of protection painting	9	45	29					1	2	2	10	49	33					1	2	1	19	47	31							1	2	2	
		faults of corrosion of structural steel	8	52	31					2	1	1	8	53	32					2	1	2	16	53	31							2	1	1	
		faults of stays, guys, connections	2	22	11					5	8	7	2	29	14					5	7	7	4	25	12							6	8	7	
		loose/missing bolts/nuts/washers	4	38	19					3	3	3	4	40	20					4	3	3	8	39	20							3	3	3	
		defeat in welds	1	14	5					7	11	11	1	15	5					10	12	12	2	15	5							9	12	12	
		faults at the connection to the foundation	1	31	13					7	4	4	1	33	15					10	5	6	2	32	14							9	4	4	
		deformation of elem. of the main supports	2	28	12					5	5	5	2	32	14					5	6	8	4	30	13							6	5	6	
		deformation in the crossarms	0	24	9					12	6	10	2	28	12					5	8	9	2	26	10							9	7	8	
		reduced tension in stay wires	3	20	11					4	9	6	2	19	9					5	10	10	5	19	10							5	9	9	
		wood deterioration	1	7	3					7	12	12	7	23	17					3	9	4	8	15	10							3	11	10	
concrete deterioration	1	23	10					7	7	8	2	34	17					5	4	4	3	28	13							8	6	5			
faults due to corrosion on small elements	1	18	9					7	10	9	1	18	9					10	11	11	2	18	9							9	10	11			
other comment																																			
percentage of supports without defect																																			
comment																																			
					85.1	76.0	95.0	99.0							82.9	65.5	87.5	99.0							84.0	70.8	91.3	99.0							
5.2	reason of collapse	due to cascade	1	22	10					6	4	6	3	23	12					3	5	4	4	23	11							6	4	5	
		due to wind loading	12	42	30					1	1	1	9	39	27					1	1	1	21	41	29							1	1	1	
		due to ice loading	3	22	11					4	5	5	2	24	12					6	4	5	5	23	12							5	5	4	
		due to wind and ice loading	6	25	16					2	3	2	6	29	19					2	2	2	12	27	17							2	2	2	
		due to conductor breakage	1	18	6					6	7	8	1	19	7					7	7	8	2	18	7							8	7	9	
		due to material defects	4	20	12					3	6	4	3	19	10					3	6	6	7	20	11							3	6	6	
		due to erection/construction faults	1	17	7					6	8	7	1	18	8					7	8	7	2	18	8							8	8	8	
		due to vandalism	3	25	13					4	2	3	3	25	13					3	3	3	6	25	13							4	3	3	
		due to delayed preventive maintenance	1	13	5					6	10	10	1	15	6					7	10	10	2	14	6							8	10	11	
		due to fatigue (conductor vibration)	0	16	5					10	9	9	1	17	7					7	9	9	1	17	6							11	9	10	
other comment																														6	11	7			
5.3	type/cause of corrosion	normal weathering	18	61	45					1	1	1	19	64	48					1	1	1	37	63	47							1	1	1	
		industrial pollution	5	40	23					5	4	2	5	46	27					2	2	2	10	43	25							2	2	2	
		maritime site (salt corrosion)	4	34	19					3	3	3	4	32	18					3	3	3	8	33	18							3	3	3	
		high humidity in tropical zones	0	8	3					8	9	9	0	10	3					7	8	8	0	9	3							9	9	9	
		in temperate zones	1	11	4					6	7	7	1	13	5					5	6	6	2	12	5							7	7	7	
		gap corrosion (pack rust)	2	15	7					4	4	4	1	19	8					5	4	5	3	17	8							6	4	4	
		inter-crystalline corrosion of material	1	12	5					6	5	6	0	12	4					7	7	7	1	12	5							8	6	8	
		heavy vegetation growth in trop. zones	0	9	3					8	8	8	0	8	3					7	9	9	0	8	3							9	10	10	
		in temp. zones	2	12	6					4	6	5	2	16	8					4	5	4	4	14	7							4	5	5	
		other comment																														4	8	6	
5.4	reason for corrosion problems	no galvanizing	5	25	15					1	1	1	5	24	15					1	3	2	10	24	15							1	3	1	
		no painting	0	18	7					5	4	5	1	23	10					5	4	4	1	20	9							6	4	6	
		no re-painting	2	23	11					3	3	2	4	29	17					2	1	1	6	26	14							3	1	2	
		inadequate detailing	0	13	5					5	6	6	1	14	5					5	6	6	1	14	5							6	7	7	
		poor erection	0	12	4					5	7	7	0	12	4					7	7	7	0	12	4							8	8	8	
		weathering steel (Corten steel)	3	17	10					2	5	4	2	18	9					3	5	5	5	17	10							4	5	5	
		low or delayed maintenance	2	23	11					3	2	3	2	26	12					3	2	3	4	25	11							5	2	4	
		other comment																														10	15	12	
5.5	subject of corrosion problem	the complete support	7	33	21					4	4	4	7	34	22					3	4	4	14	33	21							4	4	4	
		mainly the support footing area	11	42	30					1	1	1	8	38	25					2	2	3	19	40	27							1	2	1	
		connection of bars	5	28	16					5	8	7	5	26	16					5	8	8	10	27	16							5	8	8	
		gusset plates	2	27	14					10	9	9	2	21	10					9	9	9	4	24	12							10	9	9	
		size (corners of gusset plates)	4	21	13					6	10	10	2	18	9					9	10	10	6	20	11							9	10	10	
		stays	2	15	9					10	11	11	1	15	7					11	13	12	3	15	8							11	11	11	
		stay connection (ground/support)	1	11	6					12	13	12	1	15	8					11	12	11	2	13	7							12	13	12	
		lattice steel at main members	4	31	18					6	5	5	5	34	20					5	4	5	9	32	19							6	5	5	
		at secondary members	8	37	25					2	3	3	9	38	26					1	2	2	17	38	25							2	3	3	
		nuts of bolts	8	39	25					2	2	2	7	42	27					3	1	1	15	41	26							3	1	2	
shaft of bolts	3	28	16					9	7	8	5	32	19					5	6	6	8	30	17							7	6	6			
washers of bolts	4	29	17					6	6	6	4	28	17					8	7	7	8	29	17							7	7	7			
welding seams	1	13	5					12	12	13	1	16	7					11	11	13	2	15	6							12	12	13			
other comment																														14	14	14			
5.6	deformation crossarms	at the top/attachment point																																	

Table 5.5. Type and causes of defects

	<i>OHTL</i>					<i>OHDL</i>				
	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>
1	3.47	0.00	2.00	6.80	184	3.71	0.00	3.00	7.00	189
2	2.53	0.00	1.00	6.00	134	2.67	0.00	2.00	7.00	136
3	3.94	0.00	3.00	8.00	209	4.49	0.00	4.00	9.00	229
4	5.17	0.00	5.00	11.80	274	5.65	0.00	4.00	13.00	288
5	14.02	0.00	10.00	35.60	743	13.71	1.00	9.00	35.00	699
x	1.49	0.00	0.00	5.80	79	1.82	0.00	0.00	5.00	93
y	0.13	0.00	0.00	1.00	7	0.12	0.00	0.00	1.00	6
n	0.79	0.00	1.00	1.00	42	0.80	0.00	1.00	1.00	41
c	1.45	0.00	1.00	3.00	77	1.35	0.00	1.00	3.00	69
T					1749					1750
-	38.19	16.10	42.00	60.80	2024	36.86	16.00	36.00	57.00	1880

6. Inspection tools and methods

Table 6.1. Number of answers per item

y	Yes
n	No
c	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

Table 6.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
R_a, R_b	Corresponding ranking system

Table 6.3. List of answers per respondent / item for OHTL

Table 6.4. List of answers per respondent / item for OHDL

Table 6.5. Total number of answers

Table 6.1. Inspection tools and methods

			OHTL					OHDL					OHL				
			y	n	c	T	-	y	n	c	T	-	y	n	c	T	-
6.1	inspection methods	destructive inspection methods	2	38	0	40	13	2	37	0	39	12	4	75	0	79	25
		non-destructive inspection methods	45	4	0	49	4	44	4	0	48	3	89	8	0	97	7
6.1	comment	special tools used for inspection of supports?	0	0	26	26	27	0	0	23	23	28	0	0	49	49	55
		comment	26	22	0	48	5	25	23	0	48	3	51	45	0	96	8
6.1	comment	deflection of supports and torsion of supports	0	0	0	0	53	0	0	1	1	50	0	0	1	1	103
		geometry of structure (photogrammetry)	9	33	0	42	11	9	30	0	39	12	18	63	0	81	23
6.1	comment	paint thickness meter	4	37	0	41	12	2	34	0	36	15	6	71	0	77	27
		galvanize thickness meter	22	20	0	42	11	22	18	0	40	11	44	38	0	82	22
6.1	comment	steel corrosion metrology	26	17	0	43	10	26	15	0	41	10	52	32	0	84	20
		support leg corrosion detector	4	37	0	41	12	5	34	0	39	12	9	71	0	80	24
6.1	comment	guys/stay wire corrosion detector	5	35	0	40	13	7	32	0	39	12	12	67	0	79	25
		endoscopic device (steel pipe / pole)	3	35	0	38	15	4	32	0	36	15	7	67	0	74	30
6.1	comment	tension measurement of stays	1	32	0	33	20	1	34	0	35	16	2	66	0	68	36
		comment	9	26	0	35	18	8	27	0	35	16	17	53	0	70	34
6.1	comment	deflection	0	0	6	6	47	0	0	4	4	47	0	0	10	10	94
		corrosion detector	3	19	0	22	31	5	21	0	26	25	8	40	0	48	56
6.1	comment	concrete quality detector (sclerometer)	1	21	0	22	31	1	24	0	25	26	2	45	0	47	57
		concrete quality impact device (Schmidt hammer)	3	19	0	22	31	4	21	0	25	26	7	40	0	47	57
6.1	comment	surface carbonization (chemical)	4	17	0	21	32	3	20	0	23	28	7	37	0	44	60
		comment	4	18	0	22	30	5	20	0	25	25	9	38	0	47	55
6.1	comment	hammer test	0	0	2	2	51	0	0	2	2	49	0	0	4	4	100
		drilled cores	5	10	0	15	38	13	11	0	24	27	18	21	0	39	65
6.1	comment	resistograph	8	8	0	16	37	13	10	0	23	28	21	18	0	39	65
		decay drill	2	12	0	14	39	2	19	0	21	30	4	31	0	35	69
6.1	comment	comment	1	16	0	17	36	6	17	0	23	28	7	33	0	40	64
		metallurgical analysis	0	0	1	1	52	0	0	5	5	46	0	0	6	6	98
6.1	comment	chemical analysis	26	22	0	48	5	23	24	0	47	4	49	46	0	95	9
		electron-microscopic analysis	26	21	0	47	6	23	22	0	45	6	49	43	0	92	12
6.1	comment	steel properties (yield, impact)	20	25	0	45	8	15	28	0	43	8	35	53	0	88	16
		comment	21	25	0	46	7	18	27	0	45	6	39	52	0	91	13
6.1	comment	comment	0	0	2	2	51	0	0	2	2	49	0	0	4	4	100
		comment on advantages	0	0	20	20	33	0	0	19	19	32	0	0	39	39	65

Table 6.2. Inspection tools and methods (OHL)

		OHTL				OHDL				OHL						
		Sa	Sb	Ra	Rb	Sa	Sb	Ra	Rb	Sa	Sb	Ra	Rb			
6.1	inspection	destructive inspection methods		0.05	0.05	2	2	0.04	0.05	2	2	0.04	0.05	2	2	
	methods	non-destructive inspection methods		0.92	0.92	1	1	0.86	0.92	1	1	0.86	0.92	1	1	
		comment														
6.2	tools used for inspection		special tools used for inspection of supports?	0.54	0.54	2	2	0.49	0.52	2	3	0.49	0.53	2	3	
			comment													
		steel	deflection of supports and torsion of supports	0.21	0.21	5	5	0.18	0.23	4	4	0.17	0.22	4	5	
			geometry of structure (photogrammetry)	0.10	0.10	7	7	0.04	0.06	9	9	0.06	0.08	9	9	
			paint thickness meter	0.52	0.52	3	3	0.43	0.55	3	2	0.42	0.54	3	2	
			galvanize thickness meter	0.60	0.60	1	1	0.51	0.63	1	1	0.50	0.62	1	1	
			steel corrosion metrology	0.10	0.10	7	7	0.10	0.13	7	7	0.09	0.11	7	7	
			support leg corrosion detector (sclerometer)	0.13	0.13	6	6	0.14	0.18	6	6	0.12	0.15	6	6	
			guys/stay wire corrosion detector (Schmidt hammer)	0.08	0.08	9	9	0.08	0.11	8	8	0.07	0.09	8	8	
			endoscopic device (steel pipe / pole)	0.03	0.03	10	10	0.02	0.03	10	10	0.02	0.03	10	10	
		tension measurement of stays	0.26	0.26			0.16	0.23			0.16	0.24				
		comment														
		concrete	deflection	0.14	0.14	3	3	0.19	0.19	2	2	0.08	0.17	2	2	
			corrosion detector	0.05	0.05	5	5	0.04	0.04	5	5	0.02	0.04	5	5	
			concrete quality detector	0.14	0.14	3	3	0.16	0.16	3	3	0.07	0.15	3	4	
			concrete quality impact device	0.19	0.19	1	1	0.13	0.13	4	4	0.07	0.16	3	3	
			surface carbonization	0.18	0.18	2	2	0.20	0.20	1	1	0.09	0.19	1	1	
comment																
wood	hammer test	0.33	0.33	2	2	0.54	0.54	2	2	0.17	0.46	2	2			
	drilled cores	0.50	0.50	1	1	0.57	0.57	1	1	0.20	0.54	1	1			
	resistograph	0.14	0.14	3	3	0.10	0.10	4	4	0.04	0.11	4	4			
	decay drill	0.06	0.06	4	4	0.26	0.26	3	3	0.07	0.18	3	3			
comment																
6.3	special laboratory examination	metallurgical analysis	0.54	0.54	2	2	0.49	0.49	2	2	0.47	0.52	1	2		
		chemical analysis	0.55	0.55	1	1	0.51	0.51	1	1	0.47	0.53	1	1		
		electron-microscopic analysis	0.44	0.44	4	4	0.35	0.35	4	4	0.34	0.40	4	4		
		steel properties (yield, impact)	0.46	0.46	3	3	0.40	0.40	3	3	0.38	0.43	3	3		
comment																
6.4	comment on advantages															

Table 6.3. Inspection tools and methods (OHTL)

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35			
6.1	inspection methods	destructive inspection methods	n	n	n	-	n	-	-	n	n	n	n	n	n	n	n	n	n	n	n	-	n	n	n	n	y	n	n	n	n	-	-						
		non-destructive inspection methods	y	y	y	-	y	y	y	n	n	y	-	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y		
		comment	-	-	c	c	-	c	c	c	c	c	c	-	-	-	c	-	c	c	c	c	c	-	-	-	c	-	c	-	c	-	-	c	-	-	c		
6.2	tools used for inspection	steel	special tools used for inspection of supports?	n	n	-	y	-	n	n	n	y	n	n	y	n	y	n	y	y	y	y	y	y	n	n	y	y	y	y	y	n	n	n	n				
			comment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		concrete	deflection of supports and torsion of supports	n	-	n	-	-	n	n	n	y	n	n	y	n	y	-	n	n	n	n	-	-	y	n	n	n	n	n	n	n	y	-	n	-	n		
			geometry of structure (photogrammetry)	n	-	n	-	-	n	n	n	n	n	n	n	-	n	-	n	n	n	y	-	n	n	n	n	y	n	n	y	n	n	y	-	n	-	n	
			paint thickness meter	n	-	n	-	-	n	n	n	y	-	n	n	n	y	-	n	n	y	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	y	-	y
			galvanize thickness meter	n	-	n	y	-	n	n	n	y	-	n	y	n	y	-	n	y	y	-	n	y	y	y	y	n	y	y	y	y	y	y	-	y	-	y	
			steel corrosion metrology	n	-	n	y	-	n	n	n	n	-	n	y	n	n	-	n	n	n	n	n	-	-	n	n	n	n	n	n	n	n	n	n	y	n	-	n
			support leg corrosion detector	n	-	n	y	-	n	n	n	n	-	n	y	-	n	-	n	n	n	n	n	-	-	n	n	n	n	n	n	n	n	n	n	n	n	-	n
			guys/stay wire corrosion detector	n	-	n	y	-	n	n	n	n	-	n	y	n	n	-	n	n	n	n	y	-	n	n	n	n	n	n	n	n	n	n	n	n	n	-	n
			endoscopic device (steel pipe / pole)	n	-	n	-	n	n	n	n	n	-	-	n	-	n	-	n	-	n	-	n	-	-	n	n	n	y	n	n	n	n	n	n	n	-	n	
tension measurement of stays	n	-	n	-	n	n	n	n	-	-	y	-	y	-	y	-	y	-	y	-	-	n	n	n	n	n	n	n	n	n	n	n	n	n	-	n			
comment	-	-	-	c	-	-	-	-	-	-	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
6.3	special laboratory examination	deflection	n	-	n	-	n	n	-	-	y	-	-	-	-	-	n	-	n	-	-	-	n	-	-	-	-	-	n	n	-	-	-	-	-	-			
		corrosion detector	n	-	n	-	n	n	-	-	n	-	-	-	-	-	n	-	n	-	-	-	-	n	-	-	-	-	-	n	n	-	-	-	-	-	-		
		concrete quality detector (sclerometer)	n	-	n	-	n	n	-	-	y	-	-	-	-	-	n	-	n	-	-	-	-	n	-	-	-	-	-	n	n	-	-	-	-	-	-		
		concrete quality impact device (Schmidt hammer)	n	-	n	-	n	n	-	-	y	-	-	-	-	-	n	-	n	-	-	-	-	n	-	-	-	-	-	n	n	-	-	-	-	-	-		
		surface carbonization (chemical)	n	-	n	-	n	n	-	-	y	-	-	-	-	-	n	-	n	-	-	-	-	n	-	-	-	-	-	n	n	-	-	-	-	-	-		
comment	-	-	-	-	-	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-			
6.4	comment on advantages	hammer test	-	-	-	-	-	-	-	-	-	-	-	-	-	-	y	y	n	-	n	-	n	-	-	-	-	n	-	-	-	-	-	-	-	-			
		drilled cores	-	-	-	-	y	-	-	-	-	-	-	-	-	-	-	y	y	y	-	n	-	n	-	-	-	-	n	-	-	-	-	-	-	-	-		
		resistograph	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	n	y	y	-	n	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
		decay drill	-	-	-	-	-	-	n	-	-	-	-	-	-	-	-	y	n	n	-	n	-	n	-	-	-	-	-	n	-	-	-	-	-	-	-	-	
		comment	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6.3	special laboratory examination	metallurgical analysis	n	n	n	y	n	y	n	-	y	-	n	y	y	y	y	n	y	y	y	y	y	y	y	y	y	y	y	n	n	y	n	n	y	n			
		chemical analysis	n	n	n	y	n	y	n	-	y	-	n	y	y	y	y	n	y	y	y	y	y	y	y	y	y	y	y	y	n	n	y	-	n	-	n		
		electron-microscopic analysis	n	n	n	y	n	y	n	-	y	-	n	y	y	y	n	n	y	y	y	n	n	y	y	n	n	n	y	n	n	y	-	n	-	-	-	-	
		steel properties (yield, impact)	n	n	n	-	n	y	n	-	y	-	n	y	y	y	y	n	y	y	y	y	n	y	y	y	y	y	y	y	n	n	n	n	n	n	-	n	
		comment	-	-	-	-	-	-	-	-	-	c	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
6.4	comment on advantages	-	-	-	c	-	c	-	-	c	c	-	-	-	c	-	c	-	c	-	c	-	-	-	c	c	-	-	-	-	-	-	-	-	-	-			
		y	1			1	1	9	1	5	1	1	13	0	0	12	4	13	8	8	3	11		8	9	4	9	9	4		8	12	2	3					
		n	20		6	19	0	11	16	15	10	8	5	14	4	7	7	3	17	10	14		1	16	12	7	16	12		13	12	1	12	1					
		c	0		0	1	3	0	3	1	1	3	3	0	0	0	2	0	3	1	2		0	0	2	2	1	1		2	1	0	1						
		T	21		7	21	12	12	24	17	12	24	8	14	16	11	22	11	28	14	27		9	25	18	18	26	17		23	25	3	16	1					
		-	11		25	11	20	20	8	15	20	8	24	18	16	21	9	21	4	18	5		23	7	14	14	6	15		9	7	29	16	1					

Table 6.5. Inspection tools and methods

	<i>OHTL</i>					<i>OHDL</i>				
	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>
y	5.28	1.00	5.00	10.60	280	5.61	1.00	5.00	11.00	286
n	10.74	3.20	11.00	19.00	569	11.45	3.00	12.00	20.00	584
c	1.08	0.00	1.00	3.00	57	0.92	0.00	1.00	2.00	56
T					906					926
-	14.89	6.00	15.00	23.80	789	13.82	6.00	14.00	25.00	705

7. Inspection reports

Table 7.1. Number of answers per item

p	Partly yes
y	Yes (or numerical value)
n	No
c	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

Table 7.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
R_a	Ranking of score S_a
R_b	Ranking of score S_b
Mean	Mean of the array of numerical values
10 %	First decile of the array of numerical values
50 %	Median of the array of numerical values
90 %	Ninth decile of the array of numerical values

Table 7.3. List of answers per respondent / item for OHTL

Table 7.4. List of answers per respondent / item for OHDL

Table 7.5. Total number of answers

Table 7.1 Inspection reports

		OHTL					OHDL					OHL						
		y	n	c	T	-	y	n	c	T	-	y	n	c	T	-		
7.1	checklists used?	39	12	0	51	2	38	11	0	49	2	77	23	0	100	4		
	comment	0	0	22	22	31	0	0	18	18	33	0	0	40	40	64		
7.2	electronic field book used?	10	41	0	51	2	7	42	0	49	2	17	83	0	100	4		
	comment	0	0	12	12	41	0	0	13	13	38	0	0	25	25	79		
7.3	records of deformation	displacement at the top of the support	20	28	0	48	5	24	23	0	47	4	44	51	0	95	9	
		displacement of nodes	15	32	0	47	6	18	28	0	46	5	33	60	0	93	11	
		deformed/damaged profiles (+ number)	35	15	0	50	3	35	14	0	49	2	70	29	0	99	5	
		location of deformed/damaged profiles	36	14	0	50	3	36	13	0	49	2	72	27	0	99	5	
		degree of deformation	22	25	0	47	6	25	21	0	46	5	47	46	0	93	11	
		reduction in cross section	16	32	0	48	5	19	28	0	47	4	35	60	0	95	9	
		kind of profile deformation	bending	29	15	0	44	9	30	15	0	45	6	59	30	0	89	15
			buckling	25	18	0	43	10	28	17	0	45	6	53	35	0	88	16
			torsion	20	21	0	41	12	21	20	0	41	10	41	41	0	82	22
			local deformation	30	15	0	45	8	32	12	0	44	7	62	27	0	89	15
cracking	27	16	0	43	10	29	13	0	42	9	56	29	0	85	19			
comment	0	0	9	9	44	0	0	8	8	43	0	0	17	17	87			
7.4	corrosion attack: differentiation	surface extent of corrosion	39	11	0	50	3	39	9	0	48	3	78	20	0	98	6	
		depth of corrosion attack	31	18	0	49	4	29	18	0	47	4	60	36	0	96	8	
		location of corrosion attack	39	9	0	48	5	36	10	0	46	5	75	19	0	94	10	
		comment	0	0	3	3	50	0	0	5	5	46	0	0	8	8	96	
		extent of surface corrosion	27	16	0	43	10	27	15	0	42	9	54	31	0	85	19	
		low corrosion attack	23	15	0	38	15	22	13	0	35	16	45	28	0	73	31	
		percentage	0	0	0	0	37	0	0	0	0	34	0	0	0	0	71	
		medium corrosion attack	21	15	0	36	17	21	13	0	34	17	42	28	0	70	34	
		percentage	0	0	0	0	37	0	0	0	0	35	0	0	0	0	72	
		high corrosion attack	19	16	0	35	18	22	13	0	35	16	41	29	0	70	34	
percentage	0	0	0	0	39	0	0	1	1	34	0	0	1	1	73			
7.4	corrosion attack: differentiation	surface oriented rust: 90% of thickness intact	10	23	0	33	20	10	22	0	32	19	20	45	0	65	39	
		local rust attack: 70% of thickness intact	9	21	0	30	23	10	20	0	30	21	19	41	0	60	44	
		totally exposed hole in profile	6	24	0	30	23	9	21	0	30	21	15	45	0	60	44	
		comment	0	0	15	15	38	0	0	12	12	39	0	0	27	27	77	
7.5	do you categorise the results of your inspection ?	36	14	0	50	3	37	11	0	48	3	73	25	0	98	6		
	comment	0	0	27	27	26	0	0	26	26	25	0	0	53	53	51		

Table 7.5. Inspection reports

	<i>OHTL</i>					<i>OHDL</i>				
	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>
y	11.02	3.00	12.00	17.80	584	11.84	1.00	12.00	19.00	604
n	8.79	1.20	8.00	16.60	466	8.27	1.00	8.00	15.00	422
c	1.66	0.00	1.00	4.00	88	1.63	0.00	1.00	4.00	83
T					1138					1109
-	10.66	4.00	9.00	17.80	565	10.29	4.00	9.00	18.00	525

8. Assessment of inspection data

Table 8.1. Number of answers per item

p	Partly yes
y	Yes (or numerical value)
n	No
c	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

Table 8.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
R_a	Ranking of score S_a
R_b	Ranking of score S_b
Mean	Mean of the array of numerical values
10 %	First decile of the array of numerical values
50 %	Median of the array of numerical values
90 %	Ninth decile of the array of numerical values

Table 8.3. List of answers per respondent / item for OHTL

Table 8.4. List of answers per respondent / item for OHDL

Table 8.5. Total number of answers

Table 8.1. Assessment of inspection data

		OHTL							OHDL							OHL										
		p	y	n	z	c	T	-	p	y	n	z	c	T	-	p	y	n	z	c	T	-				
8.1	available documents	site maps/longitudinal profiles	0	49	3	0	0	52	1	0	48	2	0	0	50	1	0	97	5	0	0	102	2			
		support list	0	51	1	0	0	52	1	0	50	0	0	0	50	1	0	101	1	0	0	102	2			
		workshop drawings of supports	0	48	4	0	0	52	1	0	48	2	0	0	50	1	0	96	6	0	0	102	2			
		loading tree	0	43	8	0	0	51	2	0	42	6	0	0	48	3	0	85	14	0	0	99	5			
		static calculation: steel data	0	37	12	0	0	49	4	0	37	11	0	0	48	3	0	74	23	0	0	97	7			
		profiles+bolt data	0	39	10	0	0	49	4	0	38	10	0	0	48	3	0	77	20	0	0	97	7			
		support geometry	0	42	8	0	0	50	3	0	43	6	0	0	49	2	0	85	14	0	0	99	5			
		concrete quality	0	17	9	0	0	26	27	0	17	11	0	0	28	23	0	34	20	0	0	54	50			
		comment	0	0	0	0	0	8	8	45	0	0	0	0	0	6	6	45	0	0	0	0	0	14	14	90
		information for which % system: all information	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	
		some information	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	8	0	0	0	0	0	0	15	
		no information	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	11	0	0	0	0	0	0	18	
comment	0	0	0	0	0	8	8	45	0	0	0	0	0	10	10	41	0	0	0	0	0	18	18	86		
possession of as-built support drawings	0	48	4	0	0	52	1	0	45	5	0	0	50	1	0	93	9	0	0	102	2					
modification supports drawings	0	47	2	0	0	49	4	0	45	2	0	0	47	4	0	92	4	0	0	96	8					
comment	0	0	0	0	0	4	4	49	0	0	0	0	0	5	5	46	0	0	0	0	9	9	95			
8.2	load capacity	load capacity by calculation	1	43	4	0	0	48	5	0	43	3	0	0	46	5	1	86	7	0	0	94	10			
		load capacity by test	1	15	24	0	0	40	13	0	13	24	0	0	37	14	1	28	48	0	0	77	27			
		comment	0	0	0	0	0	8	8	45	0	0	0	0	0	9	9	42	0	0	0	17	17	87		
		comment if no doc available	0	0	0	0	0	11	11	42	0	0	0	0	0	14	14	37	0	0	0	0	25	25	79	
8.3	computerized data base	computerized data base	4	29	19	0	0	52	1	2	27	21	0	0	50	1	6	56	40	0	0	102	2			
		site maps	1	25	6	6	0	38	15	1	20	9	6	0	36	15	2	45	15	12	0	74	30			
		support lists	0	31	1	7	0	39	14	0	26	3	8	0	37	14	0	57	4	15	0	76	28			
		longitudinal profiles	2	26	4	7	0	39	14	2	19	8	8	0	37	14	4	45	12	15	0	76	28			
		workshop drawings of supports	0	24	7	7	0	38	15	0	18	11	7	0	36	15	0	42	18	14	0	74	30			
		loading trees	0	23	6	7	0	36	17	0	17	10	7	0	34	17	0	40	16	14	0	70	34			
		static calculation	0	18	13	5	0	36	17	0	15	15	5	0	35	16	0	33	28	10	0	71	33			
		comment	0	0	0	0	0	5	5	48	0	0	0	0	0	5	5	46	0	0	0	0	10	10	94	
		updated support list	1	25	6	7	0	39	14	0	23	7	7	0	37	14	1	48	13	14	0	76	28			
		updated longitudinal profiles	1	18	13	7	0	39	14	0	16	15	6	0	37	14	1	34	28	13	0	76	28			
		conservation state	0	14	19	4	0	37	16	0	13	18	4	0	35	16	0	27	37	8	0	72	32			
		loading and strength	1	18	11	7	0	37	16	0	15	13	8	0	36	15	1	33	24	15	0	73	31			
		refurbishment/upgrading data	0	21	9	7	0	37	16	0	16	11	8	0	35	16	0	37	20	15	0	72	32			
		comment	0	0	0	0	0	5	5	48	0	0	0	0	0	9	9	42	0	0	0	0	14	14	90	
		history data	1	21	11	4	0	37	16	1	17	13	5	0	36	15	2	38	24	9	0	73	31			
		comment	0	0	0	0	0	6	6	47	0	0	0	0	0	7	7	44	0	0	0	0	13	13	91	
		what % is computerized	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	23	0	0	0	0	0	0	44	
		comment	0	0	0	0	0	8	8	45	0	0	0	0	0	7	7	44	0	0	0	0	0	15	15	89
		GIS (Geographical Information System)	1	20	23	0	0	44	9	1	19	24	0	0	44	7	2	39	47	0	0	88	16			
		comment	0	0	0	0	0	8	8	45	0	0	0	0	0	9	9	42	0	0	0	0	17	17	87	
		8.4	assessment	decisions based on experienced techn. pers.	0	49	1	0	0	50	3	0	48	2	0	0	50	1	0	97	3	0	0	100	4	
				comment	0	0	0	0	0	7	7	46	0	0	0	0	0	6	6	45	0	0	0	0	13	13	91
decisions based on defined parameters	0			27	20	0	0	47	6	0	25	22	0	0	47	4	0	52	42	0	0	94	10			
comment	0	0	0	0	0	14	14	39	0	0	0	0	0	15	15	36	0	0	0	0	29	29	75			
8.5	design	latest design criteria for refurbishment	3	31	17	0	0	51	2	2	28	19	0	0	49	2	5	59	36	0	0	100	4			
		latest design criteria for upgrading	2	43	6	0	0	51	2	1	43	4	0	0	48	3	3	86	10	0	0	99	5			
		mix	1	16	28	0	0	45	8	0	18	27	0	0	45	6	1	34	55	0	0	90	14			
comment	0	0	0	0	0	18	18	35	0	0	0	0	0	19	19	32	0	0	0	0	37	37	67			
8.6	test	design correlated by test on individual elements	0	22	25	0	0	47	6	0	19	27	0	0	46	5	0	41	52	0	0	93	11			
		design correlated by test on entire support	0	28	21	0	0	49	4	0	21	27	0	0	48	3	0	49	48	0	0	97	7			
8.7	static analysis without any test / comment		0	22	21	0	0	43	10	0	25	20	0	0	45	6	0	47	41	0	0	88	16			
			0	0	0	0	0	11	11	42	0	0	0	0	0	17	17	34	0	0	0	28	28	76		
8.8	upgrading friendly design / easy to refurbish comment		0	33	17	0	0	50	3	0	30	18	0	0	48	3	0	63	35	0	0	98	6			
			0	0	0	0	0	20	20	33	0	0	0	0	0	16	16	35	0	0	0	36	36	68		

Table 8.2. Assessment of inspection data (OHL)

		OHTL								OHDL								OHL							
		Sa	Sb	Ra	Rb	mean	10%	50%	90%	Sa	Sb	Ra	Rb	mean	10%	50%	90%	Sa	Sb	Ra					
available documents	site maps/longitudinal profiles	0.92	0.94	2	2					0.94	0.96	2	2					0.93	0.95	2	2				
	support list	0.96	0.98	1	1					0.98	1.00	1	1					0.97	0.99	1	1				
	workshop drawings of supports	0.91	0.92	3	3					0.94	0.96	2	2					0.92	0.94	3	3				
	loading tree	0.81	0.84	4	4					0.82	0.88	5	5					0.82	0.86	4	4				
	static calculation: steel data	0.70	0.76	7	7					0.73	0.77	7	7					0.71	0.76	7	7				
	profiles+bolt data	0.74	0.80	6	6					0.75	0.79	6	6					0.74	0.79	6	6				
	support geometry	0.79	0.84	5	5					0.84	0.88	4	4					0.82	0.86	4	4				
	concrete quality	0.32	0.65	8	8					0.33	0.61	8	8					0.33	0.63	8	8				
	comment																								
	information for which % system: all information					91	75	95	100					84	57	90	100								
some information					8	0	5	23					14	0	10	40					87	66	93	100	
no information					1	0	0	5					3	0	0	10					11	0	8	31	
comment																					2	0	0	8	
possession of as-built support drawings		0.91	0.92	1	2					0.88	0.90	1	2					0.89	0.91	1	2				
	modification supports drawings	0.89	0.96	2	1					0.88	0.96	1	1					0.88	0.96	2	1				
comment																									
load capacity	load capacity by calculation	0.83	0.92	1	1					0.84	0.93	1	1					0.84	0.93	1	1				
	load capacity by test	0.30	0.40	2	2					0.25	0.35	2	2					0.28	0.38	2	2				
comment																									
comment if no document available																									
computerized data base	computerized data base	0.62	0.63							0.57	0.58							0.60	0.61						
	site maps	0.55	0.81	3	3					0.47	0.70	3	3					0.51	0.76	3	3				
	support lists	0.67	0.97	1	1					0.60	0.90	1	1					0.64	0.93	1	1				
	longitudinal profiles	0.61	0.88	2	2					0.49	0.72	2	2					0.55	0.80	2	2				
	workshop drawings of supports	0.52	0.77	4	5					0.41	0.62	4	5					0.47	0.70	4	5				
	loading trees	0.50	0.79	5	4					0.39	0.63	5	4					0.44	0.71	5	4				
	static calculation	0.38	0.58	6	6					0.33	0.50	6	6					0.35	0.54	6	6				
	comment																								
	updated support list	0.57	0.81	1	1					0.52	0.77	1	1					0.54	0.79	1	1				
	updated longitudinal profiles	0.41	0.59	3	4					0.36	0.52	3	4					0.38	0.56	3	4				
	conservation state	0.29	0.42	5	5					0.28	0.42	5	5					0.28	0.42	5	5				
	loading and strength	0.41	0.63	3	3					0.35	0.54	4	3					0.38	0.59	4	3				
	refurbishment/upgrading data	0.46	0.70	2	2					0.37	0.59	2	2					0.42	0.65	2	2				
	comment																								
	history data	0.45	0.67							0.39	0.58							0.42	0.63						
comment																									
what % is computerized					52	10	50	100					50	10	50	100					51	10	50	100	
comment																									
GIS (Geographical Information System)	0.40	0.48							0.39	0.45							0.39	0.47							
comment																									
assessment	decisions based on experienced techn. pers.	0.92	0.98							0.94	0.96							0.93	0.97						
	comment																								
decisions based on defined parameters	0.51	0.57							0.49	0.53							0.50	0.55							
comment																									
design	latest design criteria for refurbishment	0.64	0.67	2	2					0.59	0.61	2	2					0.62	0.64	2	2				
	latest design criteria for upgrading	0.85	0.88	1	1					0.86	0.92	1	1					0.86	0.90	1	1				
	mix	0.32	0.38	3	3					0.35	0.40	3	3					0.34	0.39	3	3				
comment																									
test	design correlated by test on individual elements	0.42	0.47	2	2					0.37	0.41	2	2					0.39	0.44	2	2				
	design correlated by test on entire support	0.53	0.57	1	1					0.41	0.44	1	1					0.47	0.51	1	1				
static analysis without any test	0.42	0.51							0.49	0.56							0.45	0.53							
comment																									
upgrading friendly design / easy to refurbish	0.62	0.66							0.59	0.63							0.61	0.64							
comment																									

Table 8.5. Assessment of inspection data

	<i>OHTL</i>					<i>OHDL</i>				
	<i>mean</i>	<i>0.1</i>	<i>0.5</i>	<i>0.9</i>	<i>Total</i>	<i>mean</i>	<i>0.1</i>	<i>0.5</i>	<i>0.9</i>	<i>Total</i>
p	0.38	0	0	1	20	0.20	0	0	1	10
y	20.06	13	20	28.8	1063	19.35	12	19	28	987
n	7.42	3	6	14.8	393	8.35	3	8	15	426
z	1.42	0	0	9.2	75	1.55	0	0	10	79
c	0.00	0	0	0	141	0.00	0	0	0	154
T					1692					1656
-	18.77	10.4	16	30.8	995	18.41	9	17	30	939

9. Experiences and solutions

Table 9.1. Number of answers per item

p	Partly yes
y	Yes (or numerical value)
n	No
c	Comment
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

Table 9.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
R_a	Ranking of score S_a
R_b	Ranking of score S_b
Mean	Mean of the array of numerical values
10 %	First decile of the array of numerical values
50 %	Median of the array of numerical values
90 %	Ninth decile of the array of numerical values

Table 9.3. List of answers per respondent / item for OHTL

Table 9.4. List of answers per respondent / item for OHDL

Table 9.5. Total number of answers

Table 9.1. Experiences and solutions

		OHTL							OHDL							OHL								
		p	y	n	x	c	T	-	p	y	n	x	c	T	-	p	y	n	x	c	T	-		
9.1	experience and solutions	bolted connections	0	28	18	0	0	46	7	0	28	16	0	0	44	7	0	56	34	0	0	90	14	
		riveted connections	0	4	42	0	0	46	7	0	5	38	0	0	43	8	0	9	80	0	0	89	15	
		welded connections	0	5	39	0	0	44	9	0	6	37	0	0	43	8	0	11	76	0	0	87	17	
		strengthening of corner leg	0	22	22	0	0	44	9	0	19	22	0	0	41	10	0	41	44	0	0	85	19	
		diagonals and horizontals	0	27	20	0	0	47	6	0	28	16	0	0	44	7	0	55	36	0	0	91	13	
		preference: replacement corner leg	0	20	13	0	0	33	20	0	19	13	0	0	32	19	0	39	26	0	0	65	39	
		secondary members	0	19	12	0	0	31	22	0	18	12	0	0	30	21	0	37	24	0	0	61	43	
		additional members (double pr)	0	24	10	0	0	34	18	0	19	12	0	0	31	19	0	43	22	0	0	65	37	
		ecological precautions for drilling on site	0	17	26	0	0	43	10	0	17	25	0	0	42	9	0	34	51	0	0	85	19	
		support heightening	0	23	16	0	0	39	14	0	22	15	0	0	37	14	0	45	31	0	0	76	28	
		change of support-top geometry	0	21	23	0	0	44	9	0	20	23	0	0	43	8	0	41	46	0	0	87	17	
		deteriorated concrete poles	0	6	28	0	0	34	19	0	6	27	0	0	33	18	0	12	55	0	0	67	37	
		wood poles	0	9	26	0	0	35	18	0	10	23	0	0	33	18	0	19	49	0	0	68	36	
		deteriorated wood poles in wet/air soil	0	10	22	0	0	32	21	0	10	21	0	0	31	20	0	20	43	0	0	63	41	
		stay tension	0	12	20	0	0	32	21	0	10	22	0	0	32	19	0	22	42	0	0	64	40	
		intermediate solutions	0	0	0	1	23	24	29	0	0	0	1	24	25	26	0	0	0	2	47	49	55	
repair/refurbishment	0	0	0	2	9	11	42	0	0	0	2	8	10	41	0	0	0	4	17	21	83			
protection against vandalism	0	0	0	10	23	33	20	0	0	0	11	21	32	19	0	0	0	21	44	65	39			
intermediate solutions after vandalism	0	0	0	6	24	30	23	0	0	0	3	24	27	24	0	0	0	9	48	57	47			
permanent solutions at the lower part	0	0	0	1	22	23	30	0	0	0	1	22	23	28	0	0	0	2	44	46	58			
at the higher part	0	0	0	2	16	18	35	0	0	0	1	17	18	33	0	0	0	3	33	36	68			
9.2	painting system	painting system on black steel	0	0	0	15	19	34	19	0	0	0	12	20	32	19	0	0	0	27	39	66	38	
		painting system on galvanized steel	0	0	0	9	35	44	9	0	0	0	8	34	42	9	0	0	0	17	69	86	18	
		painting material	0	0	0	0	31	31	22	0	0	0	0	30	30	21	0	0	0	0	61	61	43	
		layer thickness	0	0	0	0	32	32	21	0	0	0	0	31	31	20	0	0	0	0	63	63	41	
		surface preparation	0	0	0	0	32	32	21	0	0	0	0	32	32	19	0	0	0	0	64	64	40	
		number of coats	0	0	0	0	32	32	21	0	0	0	0	32	32	19	0	0	0	0	64	64	40	
		application method	0	0	0	0	36	36	17	0	0	0	0	35	35	16	0	0	0	0	71	71	33	
		in tropical climate: difference	0	0	0	0	1	1	52	0	0	0	0	0	0	51	0	0	0	0	1	1	103	
experience	0	0	0	0	6	6	47	0	0	0	0	6	6	45	0	0	0	0	12	12	92			
9.3	coating of steel supports	ecological precaution: lead-free material soluble component	0	30	5	0	0	35	17	0	30	5	0	0	35	15	0	60	10	0	0	70	32	
			comment	1	22	10	0	0	33	20	1	23	8	0	0	32	19	2	45	18	0	0	65	39
		painting	immediately after erection	0	0	0	0	10	10	43	0	0	0	0	11	11	40	0	0	0	0	21	21	83
			wait for weathering of galvaniz. (3 - 7 years)	2	14	20	0	0	36	17	2	16	18	0	0	36	15	4	30	38	0	0	72	32
			comment	0	0	0	0	14	14	39	0	0	0	0	14	14	37	0	24	37	0	0	61	43
			before erection	1	10	29	0	0	40	13	1	10	30	0	0	41	10	2	20	59	0	0	81	23
		if yes: all layers	0	6	9	0	0	15	38	0	8	9	0	0	17	34	0	14	18	0	0	32	72	
		1st layer	0	5	8	0	0	13	40	0	3	9	0	0	12	39	0	8	17	0	0	25	79	
		comment	0	0	0	0	12	12	41	0	0	0	0	11	11	40	0	0	0	0	23	23	81	
		cleaning	dry sand blasting	0	9	25	0	0	34	19	0	7	25	0	0	32	19	0	16	50	0	0	66	38
wet sand blasting	0		4	31	0	0	35	18	0	3	31	0	0	34	17	0	7	62	0	0	69	35		
covering support	0		3	29	0	0	32	21	0	2	30	0	0	32	19	0	5	59	0	0	64	40		
chemical preparation	0		5	27	0	0	32	21	0	7	24	0	0	31	20	0	12	51	0	0	63	41		
comment	0	0	0	0	15	15	38	0	0	0	0	16	16	35	0	0	0	0	31	31	73			
covering ground (painting, blasting)	0	15	25	0	0	40	13	0	16	22	0	0	38	13	0	31	47	0	0	78	26			
comment	0	0	0	0	10	10	43	0	0	0	0	10	10	41	0	0	0	0	20	20	84			
9.4	lifetime of painting (years)	0	0	0	0	0	0	15	0	0	0	0	0	0	13	0	0	0	0	0	0	28		
comment	0	0	0	0	9	9	44	0	0	0	0	9	9	42	0	0	0	0	18	18	86			
9.5	special coat on concrete poles against deterioration	0	1	18	0	0	19	34	0	2	18	0	0	20	31	0	3	36	0	0	39	65		
comment	0	0	0	0	1	1	52	0	0	0	0	1	1	50	0	0	0	0	2	2	102			
9.6	repair of crossarms	replaced totally	0	21	15	0	0	36	17	0	17	19	0	0	36	15	0	38	34	0	0	72	32	
		replaced in the vertical faces	0	13	17	0	0	30	23	0	10	20	0	0	30	21	0	23	37	0	0	60	44	
		replaced in the horizontal faces	0	13	17	0	0	30	23	0	11	19	0	0	30	21	0	24	36	0	0	60	44	
		provided additional profiles	0	7	21	0	0	28	25	0	7	23	0	0	30	21	0	14	44	0	0	58	46	
		replaced tip/attachment points	0	14	12	0	0	26	27	0	13	15	0	0	28	23	0	27	27	0	0	54	50	
comment	0	0	0	0	0	0	53	0	0	0	0	1	1	50	0	0	0	0	1	1	103			
9.7	experience support lifetime extension	0	22	23	0	0	45	8	0	21	23	0	0	44	7	0	43	46	0	0	89	15		
comment	0	0	0	0	18	18	35	0	0	0	0	18	18	33	0	0	0	0	36	36	68			
9.8	experience wood poles in tropical environment	0	4	38	0	0	42	11	0	4	36	0	0	40	11	0	8	74	0	0	82	22		
comment	0	0	0	0	4	4	49	0	0	0	0	4	4	47	0	0	0	0	8	8	96			

Table 9.2. Experiences and solutions (OHL)

		OHTL							QHDL							OHL												
		Sa	Sb	Ra	Rb	mean	10%	50%	90%	Sa	Sb	Ra	Rb	mean	10%	50%	90%	Sa	Sb	Ra	Rb	mean	10%	50%	90%			
9.1	experience and solutions	bolted connections	0.53	0.61	1	3				0.55	0.64	1	1						0.54	0.62	1	2						
		riveted connections	0.08	0.09	15	15				0.10	0.12	15	15						0.09	0.10	15	15						
		welded connections	0.09	0.11	14	14				0.12	0.14	13	14						0.11	0.13	14	14						
		strengthening of corner leg	0.42	0.50	5	7				0.37	0.46	6	8						0.39	0.48	5	7						
		diagonals and horizontals	0.51	0.57	2	6				0.55	0.64	1	1						0.53	0.60	2	4						
		preference: replacement corner leg	0.38	0.61	7	4				0.37	0.59	6	6						0.38	0.60	7	5						
		secondary members	0.36	0.61	8	2				0.35	0.60	8	4						0.36	0.61	8	3						
		additional members (double profiles)	0.46	0.71	3	1				0.38	0.61	5	3						0.42	0.66	4	1						
		ecological precautions for drilling on site	0.32	0.40	9	9				0.33	0.40	9	9						0.33	0.40	9	9						
		support heightening	0.43	0.59	4	5				0.43	0.59	3	5						0.43	0.59	3	6						
		change of support-top geometry	0.40	0.48	6	8				0.39	0.47	4	7						0.39	0.47	5	8						
		deteriorated concrete poles	0.11	0.18	13	13				0.12	0.18	13	13						0.12	0.18	13	13						
		wood poles	0.17	0.26	12	12				0.20	0.30	10	12						0.18	0.28	12	12						
		deteriorated wood poles in wet/air soil	0.19	0.31	11	11				0.20	0.32	10	10						0.19	0.32	11	11						
		stay tension	0.23	0.38	10	10				0.20	0.31	10	11						0.21	0.34	10	10						
		9.2	painting system	intermediate solutions																								
				repair/refurbishment																								
protection against vandalism																												
intermediate solutions after vandalism																												
permanent solutions at the lower part																												
at the higher part																												
painting system on black steel																												
painting system on galvanized steel																												
painting material																												
layer thickness																												
surface preparation																												
number of coats																												
application method																												
in tropical climate: difference																												
experience																												
9.3	coating of steel supports			ecological precaution: lead-free material	0.58	0.86	1	1				0.60	0.86	1	1						0.59	0.86	1	1				
				soluble component	0.43	0.70	2	2				0.47	0.75	2	2						0.45	0.72	2	2				
		comment																										
		immediately after erection	0.30	0.44	1	1				0.35	0.50	1	1						0.33	0.47	1	1						
		wait for weathering of galvanization (3 - 7 years)	0.23	0.39	2	2				0.24	0.40	2	2						0.23	0.39	2	2						
		comment																										
		before erection	0.21	0.28	1	3				0.22	0.27	1	2						0.21	0.27	1	3						
		if yes: all layers	0.11	0.40	2	1				0.16	0.47	2	1						0.13	0.44	2	1						
		1st layer	0.09	0.38	3	2				0.06	0.25	3	3						0.08	0.32	3	2						
		comment																										
		dry sand blasting	0.17	0.26	1	1				0.14	0.22	1	2						0.15	0.24	1	1						
		wet sand blasting	0.08	0.11	3	3				0.06	0.09	3	3						0.07	0.10	3	3						
		covering support	0.06	0.09	4	4				0.04	0.06	4	4						0.05	0.08	4	4						
		chemical preparation	0.09	0.16	2	2				0.14	0.23	1	1						0.12	0.19	2	2						
		comment																										
		covering ground (painting, blasting)	0.28	0.38						0.31	0.42								0.30	0.40								
		comment																										
9.4	lifetime of painting (years)					19.0	10.0	20.0	26.5					18.4	10.0	18.5	25.0					18.7	10.0	19.3	25.8			
		comment																										
9.5	special coat on concrete poles against deterioration		0.02	0.05						0.04	0.10							0.03	0.08									
		comment																										
9.6	repair of crossarms	replaced totally	0.40	0.58	1	1				0.33	0.47	1	1					0.37	0.53	1	1							
		replaced in the vertical faces	0.25	0.43	3	3				0.20	0.33	4	4					0.22	0.38	4	4							
		replaced in the horizontal faces	0.25	0.43	3	3				0.22	0.37	3	3					0.23	0.40	3	3							
		provided additional profiles	0.13	0.25	5	5				0.14	0.23	5	5					0.13	0.24	5	5							
		comment	0.26	0.54	2	2				0.25	0.46	2	2					0.26	0.50	2	2							
9.7	experience support lifetime extension		0.42	0.49					0.41	0.48								0.41	0.48									
		comment																										
9.8	experience wood poles in tropical environment		0.08	0.10					0.08	0.10								0.08	0.10									
		comment																										

Table 9.5. Experiences and solutions

	<i>OHTL</i>					<i>OHDL</i>				
	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>	<i>mean</i>	<i>10%</i>	<i>50%</i>	<i>90%</i>	<i>Total</i>
p	0.07	0.0	0.0	0.0	4	0.08	0.0	0.0	0.0	4
y	8.83	2.0	8.0	15.7	477	9.00	2.0	8.0	16.0	459
n	13.61	6.3	13.0	23.4	735	14.20	6.0	13.0	25.0	724
x	0.85	0.0	0.0	3.0	46	0.76	0.0	0.0	2.0	39
c	8.04	2.0	8.0	14.7	434	8.45	2.0	9.0	15.0	431
T					1696					1657
-	27.72	14.0	27.5	43.0	1497	27.73	14.0	26.0	43.0	1414

10. Suggestions for future CIGRE-Work

Table 10.1. List of answers per respondent / area to investigate – Scores

Table 10.1. - QUESTIONNAIRE - ASSESSMENT ON EXISTING OHL SUPPORTS

SUGGESTIONS FOR FUTURE CIGRE - WORK

		PRIORITY LEVEL																																						
10.1. AREA TO INVESTIGATE		1	2	3	4	5	X	Total	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
OHTL	1 Improvement tools & methods for inspections	11	7	5	1	2	3	29	-	-	-	1	-	-	-	-	2	-	3	1	-	5	1	X	1	1	1	2	-	-	-	-	-	-	1	3	2	-	X	
	2 Improvement tools & methods for assessment (data)	9	9	5	2	2	3	30	-	-	-	1	-	-	-	-	3	-	2	1	2	2	2	X	1	3	3	3	-	-	-	-	1	-	1	1	4	-	-	
	3 Determination/Measuring of actual support strength	5	5	5	6	4	1	26	-	-	-	-	1	-	-	-	2	-	4	3	1	1	3	-	3	4	5	-	-	-	-	-	-	-	4	1	2	-	-	
	4 Design improvement on footing area	5	1	7	4	7	3	27	-	-	-	-	1	X	-	-	1	-	-	3	1	2	5	-	3	3	5	-	-	-	-	-	-	-	4	3	3	-	-	
	5 Maintenance/Upgrade friendly supports	6	3	8	4	3	3	27	-	-	-	-	1	-	-	-	4	-	-	3	1	3	5	X	2	3	3	1	-	-	-	-	-	-	1	4	3	-	-	
	6 Determination corrosion state of steel poles	3	7	6	4	2	1	23	-	-	-	2	-	-	-	-	-	5	2	-	2	5	-	2	2	-	4	-	-	-	-	-	-	1	3	3	-	-		
	7 Determination state/strength of guys/stays	4	1	3	4	3	2	17	-	-	-	-	-	X	-	-	-	-	-	2	-	1	4	-	3	3	-	5	-	-	-	-	-	-	-	3	5	-	-	
	8 Other areas of interest	2	-	1	-	-	-	10	13	-	-	-	-	X	-	X	-	-	-	1	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	X	-	
OHDL	1 Improvement tools & methods for inspection	12	8	5	2	1	3	31	-	3	-	1	-	-	-	-	2	2	3	-	-	5	1	X	1	1	1	2	-	-	-	4	-	2	1	-	2	1	-	
	2 Improvement tools & methods for assessment (data)	8	11	6	1	2	3	31	-	2	-	1	-	-	-	-	3	2	2	-	-	2	2	X	1	3	3	3	-	-	-	3	1	5	1	-	4	-	-	
	3 Determination/Measuring of actual support strength	5	4	4	7	4	1	25	-	1	-	-	1	-	-	-	4	4	-	-	1	3	-	3	4	5	-	-	-	-	1	-	3	4	-	2	-	-		
	4 Design improvement on footing area	5	3	6	5	5	3	27	-	2	-	-	1	X	-	-	1	4	-	-	-	2	5	-	3	3	5	-	-	-	-	3	-	2	4	-	3	-	-	
	5 Maintenance/Upgrade friendly supports	6	3	8	4	1	3	25	-	2	-	-	1	-	-	-	3	-	-	-	3	5	X	2	3	3	1	-	-	-	3	-	4	1	-	3	-	-		
	6 Determination corrosion state of steel poles	3	8	6	5	2	1	25	-	2	-	2	-	-	-	-	3	4	5	-	-	2	5	-	2	2	-	4	-	-	-	2	-	2	1	-	3	3	-	
	7 Determination state/strength of guys/stays	3	2	3	6	3	1	18	-	1	-	-	-	-	-	-	3	4	-	-	-	1	4	-	3	3	-	5	-	-	-	2	-	-	-	-	5	2	-	
	8 Other areas of interest	2	1	1	-	-	-	10	14	-	2	-	-	X	-	X	-	-	-	1	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	X	-	
Diff.	-								-	-	-	-	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		

	10.1. AREA TO INVESTIGATE	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62
OHTL	1 Improvement tools & methods for inspections	2	-	-	3	2	-	X	5	X	3	3	-	-	2	1	-	2	1	4	-	1	-	-	-	1	-	2	-	-	-	2
	2 Improvement tools & methods for assessment (data)	2	-	-	1	3	-	X	5	X	1	2	-	-	-	2	-	2	4	5	-	2	-	-	-	1	-	3	-	-	-	4
	3 Determination/Measuring of actual support strength	2	-	-	4	5	-	-	5	X	4	4	-	-	-	5	-	2	3	2	-	-	-	3	-	1	-	4	-	-	-	3
	4 Design improvement on footing area	3	-	-	5	5	X	-	5	X	-	4	-	-	-	5	-	1	5	3	-	4	-	-	4	1	-	3	-	-	-	3
	5 Maintenance/upgrade friendly supports	4	-	-	3	1	-	X	5	X	-	2	-	-	2	3	-	4	5	-	-	-	-	-	3	1	-	2	-	-	-	3
	6 Determination corrosion state of steel poles	3	-	-	2	4	-	-	3	X	-	3	-	-	4	3	-	4	2	1	-	-	-	-	-	1	-	-	-	-	-	2
	7 Determination state/strength of guys/stays	4	-	-	4	-	-	-	1	X	-	-	-	-	-	4	-	5	1	-	-	-	-	-	-	1	-	-	-	-	-	3
	8 Other areas of interest	-	-	-	-	-	X	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	3	-	X	X	1	-	-	-	-	-
OHDL	1 Improvement tools & methods for inspection	2	-	1	3	2	-	X	-	X	3	3	-	-	-	1	-	2	-	4	-	1	-	-	-	1	4	-	3	1	-	-
	2 Improvement tools & methods for assessment (data)	2	-	1	1	3	-	X	-	X	1	2	-	-	-	2	-	2	-	5	-	2	-	-	-	1	3	-	4	2	-	-
	3 Determination/Measuring of actual support strength	2	-	5	4	5	-	-	-	X	4	4	-	-	-	5	-	2	-	2	-	-	-	3	-	1	4	-	4	5	-	-
	4 Design improvement on footing area	3	-	4	5	5	X	-	-	X	-	4	-	-	-	5	-	1	-	3	-	4	-	-	1	1	2	-	4	4	-	-
	5 Maintenance/upgrade friendly supports	4	-	3	3	1	-	X	-	X	-	2	-	-	-	4	-	4	-	-	-	-	-	-	1	1	-	-	3	-	1	-
	6 Determination corrosion state of steel poles	3	-	3	2	4	-	-	-	X	-	3	-	-	-	4	-	4	-	1	-	-	-	-	-	1	-	-	3	3	-	-
	7 Determination state/strength of guys/stays	4	-	4	4	-	-	-	-	X	-	-	-	-	-	4	-	5	-	-	-	-	-	-	-	1	3	-	3	-	-	-
	8 Other areas of interest	-	-	-	-	-	X	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	3	-	X	X	1	3	-	-	-	-
Diff.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-	-	-	Y	-	-	-	-	-	-	-

APPENDIX C

ENCLOSURE C.1.

GUYED STRUCTURES

C.1.1. Number of answers per item

1 – 5	Priority level (1 = most important)
x	Priority level not mentioned
y	Yes
n	No
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

C.1.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
S_1	Absolute number of priority level 1
S_2	Arithmetic weighted score for the priority levels
S_3	Geometric weighted score for the priority levels
$R_a, R_b,$	Corresponding ranking system
R_1, R_2, R_3	

C.1.3. List of answers per respondent / item

Table C.1.1 - Guyed structures - number of answers												
			1	2	3	4	5	X	Y	N	T	-
OHTL												
5.1.	FAULTS	Stays, Guys, connections	2	2	2	1	6	1			14	5
		Reduced tension in stay	3	2	3	3	3	0			14	5
5.5	CORROSION	Stays (cable)	1	2	2	2	2	0			9	10
		Stay connection (at ground and support)	1	2	1	2	4	0			10	9
6.2.	INSP. TOOLS	Corrosion detector guys							3	11	14	5
		Tension measurement							7	6	13	6
9.1.	EXPER/SOLUT	Stay tension							11	3	14	5
OHDL												
5.1.	FAULTS	Stays, Guys, connections	0	0	0	2	0	1			3	2
		Reduced tension in stay	0	0	0	2	1	0			3	2
5.5	CORROSION	Stays (cable)	0	0	1	0	1	0			2	3
		Stay connection (at ground and support)	0	0	0	0	2	0			2	3
6.2.	INSP. TOOLS	Corrosion detector guys							2	1	3	2
		Tension measurement							2	1	3	2
9.1.	EXPER/SOLUT	Stay tension							2	1	3	2
OHL												
5.1.	FAULTS	Stays, Guys, connections	2	2	2	3	6	2			17	7
		Reduced tension in stay	3	2	3	5	4	0			17	7
5.5	CORROSION	Stays (cable)	1	2	3	2	3	0			11	13
		Stay connection (at ground and support)	1	2	1	2	6	0			12	12
6.2.	INSP. TOOLS	Corrosion detector guys							5	12	17	7
		Tension measurement							9	7	16	6
9.1.	EXPER/SOLUT	Stay tension							13	4	17	7

Table C.1.2 - Guyed structures - Ranking per item												
			S _a	S _b	S ₁	S ₂	S ₃	R _a	R _a	R ₁	R ₂	R ₃
OHIL												
5.1.	FAULTS	Stays, Guys, connections Reduced tension in stay			2 3	36 27				2 1	3 1	3 1
5.5	CORROSION	Stays (cable) Stay connection (at ground and support)			1 1	39 25	23 14			3 4	2 4	2 4
6.2.	INSP. TOOLS	Corrosion detector guys Tension measurement	16 37	21 54				2 1	2 1			
9.1.	EXPER/SOLUT	Stay tension	58	79				1	1			
OHDL												
5.1.	FAULTS	Stays, Guys, connections Reduced tension in stay			0 0	26 20	9 5				1 2	1 3
5.5	CORROSION	Stays (cable) Stay connection (at ground and support)			0 0	16 8	6 2				3 4	2 4
6.2.	INSP. TOOLS	Corrosion detector guys Tension measurement	40 40	67 67				1 1	1 1			
9.1.	EXPER/SOLUT	Stay tension	40	67				1	1			
OHL												
5.1.	FAULTS	Stays, Guys, connections Reduced tension in stay			2 3	34 38	19 23				2 1	2 1
5.5	CORROSION	Stays (cable) Stay connection (at ground and support)			1 1	24 22	13 14				3 4	3 4
6.2.	INSP. TOOLS	Corrosion detector guys Tension measurement	21 38	29 56				2 1	2 1			
9.1.	EXPER/SOLUT	Stay tension	54	76				1	1			

Tabel C.1.3. - Guyed structures - List of answers per respondent / item																						
OHTL		1	6	12	14	15	16	17	18	20	32	33	39	40	47	49	50	55	56	61	62	
5.1.	FAULTS	Stays, Guys, connections	5	X	-	5	5	5		3	-	5	-	2	5	1	-	-	3	1	2	4
		Reduced tension in stay	3	-	1	3	-	4		3	-	5	-	4	2	1	4	5	5	-	1	2
5.5	CORROSION	Stays (cable)	1	-	-	5	4	-		4	3	5	-	2	2	-	-	-	-	-	-	3
		Stay connection (at ground and support)	4	-	-	5	4	-		1	5	5	-	2	5	-	-	-	-	-	2	3
6.2.	INSP. TOOLS	Corrosion detector guys	N	Y	-	Y	N	N		N	Y	N	-	N	-	N	-	N	N	-	N	N
		Tension measurement	N	-	-	Y	-	Y		Y	Y	N	-	N	Y	N	-	Y	N	-	N	Y
9.1.	EXPER/SOLUT	Stay tension	Y	-	-	Y	N	N		Y	Y	Y	Y	-	Y	Y	-	N	-	Y	Y	Y
OHDL		1	6	12	14	15	16	17	18	20	32	33	39	40	47	49	50	55	56	61	62	
5.1.	FAULTS	Stays, Guys, connections		X				4	4		-											
		Reduced tension in stay		-				4	4		5		-									
5.5	CORROSION	Stays (cable)		-				-	5		3		-									
		Stay connection (at ground and support)		-				-	5		5		-									
6.2.	INSP. TOOLS	Corrosion detector guys		Y				N	-		Y		-									
		Tension measurement		-				Y	-		Y		N									
9.1.	EXPER/SOLUT	Stay tension		-				N	-		Y		Y									

APPENDIX C

ENCLOSURE C.2.

CONCRETE POLES

C.2.1. Number of answers per item

1 – 5	Priority level (1 = most important)
x	Priority level not mentioned
y	Yes
n	No
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

C.2.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
S_1	Absolute number of priority level 1
S_2	Arithmetic weighted score for the priority levels
S_3	Geometric weighted score for the priority levels
$R_a, R_b,$	Corresponding ranking system
R_1, R_2, R_3	

C.2.3. List of answers per respondent / item

Table C.2.1 - Concrete poles - number of answers												
			1	2	3	4	5	X	Y	N	T	-
OHTL												
5.1.	FAULTS	Concrete deterioration	0	1	0	1	1	0			3	3
6.2.	INSP. TOOLS	Pole deflection							1	2	3	3
		Detector of corrosion							0	3	3	3
		Detector of concrete quality							0	3	3	3
		Concrete impact device							0	2	2	4
		Surface carbonation							0	3	3	3
9.1.	EXPER/SOLUT	Concrete deterioration							2	3	5	1
OHDL												
5.1.	FAULTS	Concrete deterioration	2	2	2	2	6	1			15	3
6.2.	INSP. TOOLS	Pole deflection							5	9	14	4
		Detector of corrosion							0	13	13	5
		Detector of concrete quality							3	11	14	4
		Concrete impact device							2	10	12	6
		Surface carbonation							3	11	14	4
9.1.	EXPER/SOLUT	Concrete deterioration							6	9	15	3
OHL												
5.1.	FAULTS	Concrete deterioration	2	3	2	3	7	1			18	6
6.2.	INSP. TOOLS	Pole deflection							6	11	17	7
		Detector of corrosion							0	16	16	8
		Detector of concrete quality							3	14	17	7
		Concrete impact device							2	12	14	10
		Surface carbonation							3	14	17	7
9.1.	EXPER/SOLUT	Concrete deterioration							8	12	20	4

Table C.2.2 - Concrete poles - Ranking per item												
			S _a	S _b	S ₁	S ₂	S ₃	R _a	R _b	R ₁	R ₂	R ₃
OHTL												
5.1.	FAULTS	Concrete deterioration			0	23	11			1	1	1
6.2.	INSP. TOOLS	Pole deflection	17	33				1	1			
		Detector of corrosion	0	0				3	3			
		Detector of concrete quality	0	0				3	3			
		Concrete impact device	0	0				2	2			
		Surface carbonation	0	0				2	2			
9.1.	EXPER/SOLUT	Concrete deterioration	33	40				1	1			
OHDL												
5.1.	FAULTS	Concrete deterioration			2	41	24			1	1	1
6.2.	INSP. TOOLS	Pole deflection	28	36				1	1			
		Detector of corrosion	0	0				5	5			
		Detector of concrete quality	17	21				2	2			
		Concrete impact device	11	17				4	4			
		Surface carbonation	17	21				2	2			
9.1.	EXPER/SOLUT	Concrete deterioration	33	40				1	1			
OHL												
5.1.	FAULTS	Concrete deterioration			2	36	20			1	1	1
6.2.	INSP. TOOLS	Pole deflection	25	35				1	1			
		Detector of corrosion	0	0				5	5			
		Detector of concrete quality	13	18				2	2			
		Concrete impact device	8	14				4	4			
		Surface carbonation	13	18				2	2			
9.1.	EXPER/SOLUT	Concrete deterioration	33	40				1	1			

Table C.2.3. - Concrete poles - List of answers per respondent / item																				
OHTL		1	4	6	9	11	14	15	20	32	37	40	44	46	47	50	54	57	59	60
5.1.	FAULTS	Concrete deterioration	4	2			-	5					-			-				
6.2.	INSP. TOOLS	Pole deflection	N	-			-	-					Y			N				
		Detector of corrosion	N	-			-	-					N			N				
		Detector of concrete quality	N	-			-	-					N			N				
		Concrete impact device	N	-			-	-					-			N				
		Surface carbonation	N	-			-	-					N			N				
9.1.	EXPER/SOLUT	Concrete deterioration	Y	Y			N	N					-			N				
OHDL		1	4	6	9	11	14	15	20	32	37	40	44	46	47	50	54	57	59	60
5.1.	FAULTS	Concrete deterioration		2	-	5	1	5	5	4	4	3	-	X	2	-	5	3	5	1
6.2.	INSP. TOOLS	Pole deflection	N	-	N	Y	Y	-	N	N	N	Y	Y	-	Y	N	N	N	N	-
		Detector of corrosion	N	-	N	N	N	-	N	N	N	-	N	-	N	N	N	N	N	-
		Detector of concrete quality	N	-	N	Y	N	-	N	N	N	Y	N	-	Y	N	N	N	N	-
		Concrete impact device	N	-	N	Y	N	-	N	N	N	-	-	-	Y	N	N	N	N	-
		Surface carbonation	N	-	N	Y	N	-	N	N	N	Y	N	-	Y	N	N	N	N	-
9.1.	EXPER/SOLUT	Concrete deterioration		Y	-	N	Y	N	N	N	N	Y	-	N	Y	N	N	-	N	Y

APPENDIX C

ENCLOSURE C.3.

WOOD POLES

C.3.1. Number of answers per item

1 – 5	Priority level (1 = most important)
x	Priority level not mentioned
y	Yes
n	No
T	Sub-total of number of preceding answers
-	No answer available, not applicable, etc.

C.3.2. Ranking of items

S_a	Score of ratio : yes / number of respondents
S_b	Score of ratio : yes / (yes + no)
S_1	Absolute number of priority level 1
S_2	Arithmetic weighted score for the priority levels
S_3	Geometric weighted score for the priority levels
$R_a, R_b,$	Corresponding ranking system
R_1, R_2, R_3	

C.3.3. List of answers per respondent / item

Table C.3.1 - Wood poles - number of answers												
			1	2	3	4	5	X	Y	N	T	-
OHTL												
5.1.	FAULTS	Wood deterioration	1	0	1	1	1	0			4	3
6.2	INSP. TOOLS	Hammer test							3	2	5	2
		Drilled cores							5	1	6	1
		Resistograph							3	3	6	1
		Decay drill							1	4	5	2
9.1.	EXPER/SOLUT	Wood deterioration						2	3	5	2	
9.8.		In tropical environment						1	4	5	2	
OHDL												
5.1.	FAULTS	Wood deterioration	7	0	2	2	3	1			15	3
6.2.	INSP. TOOLS	Hammer test							10	6	16	2
		Drilled cores							9	7	16	2
		Resistograph							3	12	15	3
		Decay drill							5	9	14	4
9.1.	EXPER/SOLUT	Wood deterioration						7	7	14	4	
9.8.		In tropical environment						2	10	12	6	
OHL												
5.1.	FAULTS	Wood deterioration	8	0	3	3	4	1			19	6
6.2.	INSP. TOOLS	Hammer test							13	8	21	4
		Drilled cores							14	8	22	3
		Resistograph							6	15	21	4
		Decay drill							6	13	19	6
9.1.	EXPER/SOLUT	Wood deterioration						9	10	19	6	
9.8.		In tropical environment						3	14	17	8	

Table C.3.2 - Wood poles - Ranking per item												
			S _a	S _b	S ₁	S ₂	S ₃	R _a	R _b	R ₁	R ₂	R ₃
OHTL												
5.1.	FAULTS	Wood deterioration			1	31	20			1	1	1
6.2.	INSP. TOOLS	Hammer test	43	60				3	2			
		Drilled cores	71	83				1	1			
		Resistograph	43	50				2	3			
		Decay drill	14	20				4	4			
9.1.	EXPER/SOLUT	Wood deterioration	29	40				1	1			
9.8.		In tropical environment	14	20				2	2			
OHDL												
5.1.	FAULTS	Wood deterioration			7	56	45			1	1	1
6.2.	INSP. TOOLS	Hammer test	56	63				1	1			
		Drilled cores	50	56				2	2			
		Resistograph	17	21				4	4			
		Decay drill	28	36				3	3			
9.1.	EXPER/SOLUT	Wood deterioration	39	50				1	1			
9.8.		In tropical environment	11	17				2	2			
OHL												
5.1.	FAULTS	Wood deterioration			8	49	38			1	1	1
6.2.	INSP. TOOLS	Hammer test	52	62				2	2			
		Drilled cores	56	64				1	1			
		Resistograph	24	29				4	4			
		Decay drill	24	32				3	3			
9.1.	EXPER/SOLUT	Wood deterioration	36	47				1	1			
9.8.		In tropical environment	12	18				2	2			

Table C.3.3. - Concrete poles - List of answers per respondent / item																				
OHTL		9	14	16	17	18	20	30	32	37	38	40	47	50	51	52	53	55	61	
5.1.	FAULTS	Wood deterioration	-	4	3	1					-			-	5					
6.2.	INSP. TOOLS	Hammer test	-	Y	Y	N					-			Y	N					
		Drilled cores	-	Y	Y	Y					N			Y	Y					
		Resistograph	-	N	Y	Y					Y			N	N					
		Decay drill	-	Y	N	N					-			N	N					
9.1.	EXPER/SOLUT	Wood deterioration	N	N	-	Y				-			N	Y						
9.8.		In tropical environment	Y	N	-	-				N			N	N						
OHDL		9	14	16	17	18	20	30	32	37	38	40	47	50	51	52	53	55	61	
6.2.	FAULTS	Wood deterioration	1	1	4	3	1	5	-	5	-	X	4	1	1	3	1	5	-	1
	INSP. TOOLS	Hammer test	Y	N	Y	Y	N	N	Y	-	Y	-	N	Y	Y	N	N	Y	Y	Y
		Drilled cores	Y	N	Y	Y	Y	N	Y	-	Y	N	N	N	Y	Y	Y	-	N	N
		Resistograph	N	N	N	Y	Y	N	-	-	N	Y	N	N	N	N	N	-	N	N
		Decay drill	Y	N	Y	N	N	N	N	-	Y	-	-	N	N	N	Y	-	N	Y
9.1.	EXPER/SOLUT	Wood deterioration	N	N	N	-	Y	N	-	Y	N	Y	Y	N	Y	N	Y	-	Y	
		In tropical environment	N	Y	N	-	-	N	N	-	N	-	-	N	N	N	N	-	Y	-