

**454**

# **Hydrogenerators Fire Protection Update**

**Working Group**

**A1. 04**

**April 2011**



# Hydrogenerators Fire Protection Update

## Working Group

### A1.04

## Volume I

## Main Part

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**ISBN: 978- 2- 85873- 143-5**

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**Legend:**

- ★- Special Contributor
- 1- Contributed in the issue of the Questionnaire
- 2- Filled Questionnaire out
- 3- Participated in the evaluation of 2008
- 4- Participated in the evaluation of 2009
- 5- Participated in the evaluation of 2010
- 6- Contributed otherwise.

Note 1: For the 2008, 2009 and 2010 intermediate stages of this UPDATE the partial results were presented on a special Internet site and the involved colleagues were invited to evaluate and comment that specific stage. The results of these evaluations were presented during the meetings of Paris 2008, Sidney 2009 and Paris 2010 respectively. All three evaluations showed positive results indicating approval of the GFP UPDATE.

Note 2: In fact there are some more contributors that sent their contributions without the indications of names, only of companies. The final list could be larger.

Note 3: The indicated numbers that appear in the text in superscript form are described in Volume II.

**The Convener sends congratulations to all participants mentioned herewith or not and thanks to those who invested their time to help the technical community with their valuable contributions.**

Alexander Gromow  
São Paulo/Brazil  
December 2010

# VOLUME I

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## **A – EXECUTIVE SUMMARY:**

*“With the absence of international standards or recommendations the philosophy for application of fire extinguishing installations varies considerably. The decisions are mostly taken individually based on own positive or negative experience, tradition or request of law and insurance companies respectively.” SIC Dr. Rolf-Dieter Kranz, 1981.*

As decided by the Study Committee A1 the former survey made in 1981 by Dr. R.D. Kranz (published in 1985 by the Nr. 103 of Electra under the name of “Fire extinguishing in large salient pole machines<sup>1”</sup>) should be UPDATED with emphasis to hydro generators.

The present work is this UPDATE took five years and was made respecting the initial work but enlarging the survey field to correlated areas in order to open new possibilities of experience gathering. The final UPDATE got answers that allowed surveying the following groups:

<b>Nr.</b>	<b>Group</b>
1	Generator user (owner)
2	Generator Manufacturer
3	Insurance Company, Reinsurance Company or Insurance Broker
6	Consulting Companies

From the originally planned 6 Groups, the answers received for Group 4 - Erection, Commissioning, Refurbishment, Maintenance, and Group 5 - Research Centers and Universities did not fulfill the requirements to participate in UPDATE.

*This UPDATE shows that the applied philosophies continue to be very different and their discussion cannot be easily made. One can wonder what could be the “root cause” of these differences and can speculate among cultural background, fear of risks, economic calculations, etc...*

*After five years of involvement with this UPDATE it become clear that in many cases there is need of deeper and better founded knowledge on the subject GFP by the involved personnel. Insufficient knowledge probably leads to the “blind” acceptance of some myths that lack of technical and practical fundaments.*

*The decision of using GFP should not be immediately considered as “fear” but in fact it uses to be a combination of: following the standards recommendations, insurance like philosophy and economic evaluation concerning the swift resuming of generation after a fire accident, just to mention those that seem to be the key aspects.*

*Nowadays many decisions are driven by globalized economical thinking leading to the search of the most economic solutions that have not to be necessarily the safest ones...*

*The philosophical conflict is getting bigger and bigger. This study provides elements that would allow starting further philosophy discussions.*

## **B – METHODOLOGY:**

Following to the CIGRÉ’s tradition as it was informed to this Convener the data for this work was collected by means of a questionnaire<sup>2</sup> in English written in MS Word. Thus the first task was to establish the questionnaire, get the comments from the interested parties and define the final version to be distributed asking for contributions.

Here the language barrier problem was clearly detected; this shows the necessity of improvement in the communications area. The Convener in this case did communicate with many fellow colleagues in several languages in order to offer support as far as possible the understanding.

The questionnaire had two types of questions:

- Check-box type that were directly statistically treated, and
- Open questions that implied in more elaborated processing due to the diversity of answers; the method of grouping the similar answers under categories (categorization) was used widely. This allowed the issue of graphics also for open questions. Although this type of questions result in a great amount of work, when compared with check-box questions, their contribution to get valuable information from the involved contributors is significant and brought interesting data to this UPDATE.

An Internet based Working Page was established at the very beginning of the work to support the distributions of the questionnaire and related documents and later on to collect all received answers in a completely transparent work that could be followed by the involved parties. The address of this page is: <http://www.gromow.com/CIGRE/working-page.htm> . Some of the documents references that will be made later on will relay to this Internet page.

The work was done based on a pyramid principle; it means each Regular and Observer Member received a personalized letter with information and the questionnaire to be distributed to their national contacts. But this scheme did not work fully due to lack of involvement of these Members and the Convener had to assume direct contacts with potential contributors.

The final statistics answers received from 20 countries, per group and per country reaching the total of 65 individual group sections answered can be seen on the table bellow:

	Statistics						
	Number of fulfilled Questionnaires						
	Legend on answered Groups: (1)-Owner (2)-Manufacturer (3)-Insurance &... (4)-Maintenance &... (5)-Universities &... (6)-Consulting						
	1	2	3	4	5	6	total
Australia	1		1				2
New Zealand	2			2			4
United Kingdom						2	2
Switzerland	3	1				1	5
Sweden	4		1			3	8
Norway	1	1	1			1	4
Canada	3	1					4
China	1	1	1	1		1	5
Spain	1						1
Russia	1						1
Japan	3	2			1		6
Germany	1		1			1	3

Brazil	7	1		1			9
USA	1	1					2
Mexico	2						2
France		1					1
Poland	1						1
Macedonia	1						1
Belgium					1		1
Austria	2	1					3
<b>Total of 20 Countries participated</b>	<b>35</b>	<b>10</b>	<b>5</b>	<b>4</b>	<b>2</b>	<b>9</b>	<b>65</b>

All Regular and Observer Members from the 35 countries indicated by the former secretary in 2005 were addressed individually with a dedicated package of information and documents related on how to understand this particular survey and how to motivate the national fellow members<sup>3</sup>, and follow up was made on all of them. Eight (8) Regular Members did either not answer at all, not get any answer from their fellow members or simply decided not to participate; these countries are: South Africa, Italy, Korea, India, Finland, Serbia & Montenegro, Argentina and Romania. In addition to that the Malaysian address did not respond. In the case of the Observer members four (4) did not participate: Algeria, Venezuela, Egypt and Croatia. The Libyan address did not work. Israel did participate in the questionnaire preparation phase with a significative collaboration but could not send any answer because there is no hydropower station in that country.

Efforts were made to spot the Malaysian and Libyan representatives without success. A complete situation of the participation and receipt of answers was always given by means of a table available at the Internet Working Page<sup>4</sup>.

It is to point out that the suggested working scheme did depend upon the support of the Regular and Observer Members to get answers specifically to the groups:

3	Insurance Company, Reinsurance Company or Insurance Broker
4	Erection, Commissioning, Refurbishment, Maintenance.
5	Research Centers and Universities

Since these groups usually are not CIGRÉ members, in a certain way this applies also to the group:

6	Consulting Companies
---	----------------------

For these groups a special action of address survey and contact action was required. Working schemes and letter models for this action were provided by the Convener. But the result show that a reasonable success rate of this initiative was not achieved, being so the group 4 Erection, Commissioning, Refurbishment, Maintenance and group 5 Research Centers and Universities did not show any useful result and cannot be considered. The statistic shows the performance of each involved group:

	<b>Group</b>	<b>Answers received</b>
4	Erection, Commissioning, Refurbishment, Maintenance.	4
5	Research Centers and Universities	2

The **Group 4 - Erection, Commissioning, Refurbishment, Maintenance**, had 4 answers and 3 of them confirmed not to have you dealt with hydro generators that were damaged by fire; thus they could not fulfill the requirements to participate in this work.

One Company from New Zealand, coded EMP015, did work on machines damaged by fire and answered with yes to the question: "In your experience, have you dealt with hydro generators that were damaged by fire?" Since they also fulfilled the questionnaire as Users their answer as Refurbishment Company did rely to some of its Group 1's answers. As a general statement and answering to the exploratory question "If yes, please indicate the tasks you were involved with and list some basic machine data of the equipment itself" they informed the following: "*Decide the solution/repair method, produce any specification required and supervise the repair work and project management. Obviously in the earlier days also did all tasks to show workers how I wanted things done. The most recent machines were 45MVA - 4 parallel circuit lap wound units, that had been resin injected, to fill internal voids and prolong the life. The two units before that were 120MW units with epoxy windings, but had unusual endwinding taping system that was susceptible to moisture absorption. The 1984 unit was a 36MW wave wound unit with an epoxy winding and polyester caps.*" It was not possible to derive any conclusion on the Group 4 that ended not being considered in this work.

The **Group 5 - Research Centers and Universities** had 2 answers but none of the Research Centers did participate in any survey made specifically concerning the flammability of existing materials nowadays used in hydro generators manufacture. And therefore they did not meet the basic criteria to be of interest to this survey, that was to pursue any available testing made on modern insulating components do check their behavior towards fire. The intention was to check the statements Manufacturers use to make concerning the non flammability conditions of their products. In fact there may be differences between the insulation material components as raw materials and the final product, for instance stator bars, considering the handling during manufacture an erection works; but this aspect could not be checked this time.

Here we call the attention to the fact of the responsibility involved in the motivational effort to be made by the Convener in such a work involving several countries, different languages and philosophies. The *A1 Study Committee former Secretary* this issue with the following sentence: "***We should always keep in mind that the National Members (and Observer Members) are responsible for answers***", and on the top of that all possible support was given in this case, as well as additional support was offered.

**C – INDIVIDUAL ITEM ANALYSIS:** the survey made through the questionnaires divided in six groups allowed interesting comparative analysis from similar aspects seen by different groups. Other questions were made for specific groups and were considered separately.

Generator Fire Protection is a very specific subject and the equalization of the answers required a special effort. In some cases the equalization was started as soon as the answers were received, but during the compilation of the statistical values a second round of equalization questions was required. In the example below only 8 out of 36 of the sent questions were not answered by the involved parties, in spite of several requests sent to each one of the involved colleagues, as can be seen at the table below:

No.	Question to	sent on	answer on
1	Company coded EMP 029 from Australia	25/03/08	27/03/08
2	Company coded EMP 054 from Austria	24/03/08	07/04/08
3	Company coded EMP 051 from Austria	24/03/08	
4	Company coded EMP 016 from Brazil	24/03/08	09/04/08
5	Company coded EMP 020 from Brazil	22/01/08	11/04/08
6	Company coded EMP 025 from Brazil	25/03/08	17/04/08
7	Company coded EMP 045 from Brazil	26/02/08	30/03/08

8	Company coded EMP 010 from Canada	25/03/08	01/04/08
9	Company coded EMP 032 from Canada	02/10/07	09/10/07
10	Company coded EMP 036 from Canada	18/09/07	21/09/07
11	Company coded EMP 021 from China	25/03/08	
12	Company coded EMP 003 from France	26/03/08	27/03/08
13	Company coded EMP 048 from Germany	24/03/08	04/04/08
14	Company coded EMP 028 from Japan	27/03/08	06/04/08
15	Company coded EMP 027 from Macedonia	21/02/08	26/02/08
16	Company coded EMP 012 from Mexico	27/03/08	
17	Company coded EMP 031 from Mexico	27/03/08	
18	Company coded EMP 015 from New Zealand	28/03/08	06/04/08
19	Company coded EMP 033 from New Zealand	29/03/08	31/03/08
20	Company coded EMP 004 from Norway	28/03/08	18/04/08
21	Company coded EMP 042 from Norway	28/03/08	09/04/08
22	Company coded EMP 053 from Poland	30/03/08	
23	Company coded EMP 023 from Spain	25/03/08	23/04/08
24	Company coded EMP 019 from Sweden	30/03/08	16/05/08
25	Company coded EMP 026 from Sweden	30/03/08	
26	Company coded EMP 041 from Sweden	30/03/08	07/04/08
27	Company coded EMP 041a from Sweden	30/03/08	
28	Company coded EMP 049 from Sweden	30/03/08	11/05/08
29	Company coded EMP 001 from Switzerland	31/03/08	
30	Company coded EMP 005 from Switzerland	05/01/08	07/01/08
31	Company coded EMP 006 from Switzerland	31/03/08	16/04/08
32	Company coded EMP 011 from Switzerland	31/03/08	03/04/08
33	Company coded EMP 056 from Switzerland	07/03/08	12/03/08
34	Company coded EMP 055 from USA	12/02/08	15/02/08
35	Company coded EMP 018 from USA	23/09/07	24/10/07

## D – STUDY OF THE GROUP 1- USERS’ ANSWERS:

This is the second step of this task and the biggest one considering the 35 users that contributed with their valuable participation concerning the **Group 1 - Users**. We will follow the item numbering of the first part as well as the item numbers of the original Questionnaire. The index of this part of the GFP UPDATE is as follows:

### D 1 – Questionnaire with focus on Users of Hydro Generators (owners):

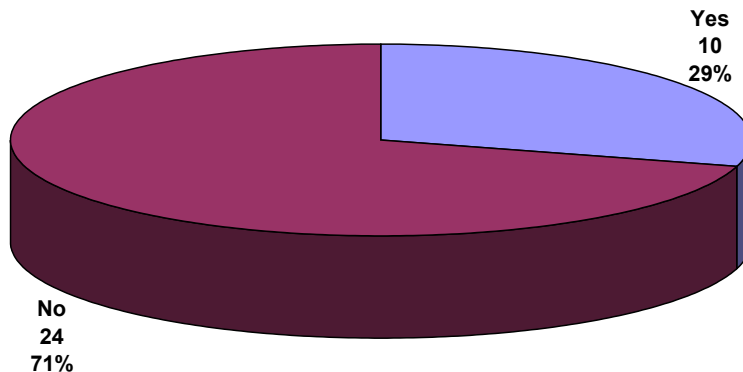
Now passing to the detailed discussion of each item, not forgetting that the pertinent tables with the statistical records of all items are shown in the annex, we have:

#### D 1.1 -

<p>1.1) Are there standards recommending generator fire protection (GFP) in your country?  <input type="checkbox"/> - Yes   <input type="checkbox"/> - No</p>
---

This question was made as a check-box question with Yes and No alternative, and for this group the answers resulted in the following graphic (the corresponding questionnaires and the resulting statistical tables are available in the corresponding annexes):

**1.1 - Are there standards recommending generator fire protection (GFP) in your country?**



This survey has 1 Blank answer – not considered in the graph.

This shows that the majority (68%) of the answers indicated that no local standards exist.

We repeat the consideration made formerly: this question raised some polemic since many non Americans answered considering NFPA as national standard which of course cannot be accepted in this case. By the way the Convener's comment to this issue is that the NFPA standards are still really the state of the art in this case and could within some boundaries be considered as "global standards" – but the question's intention was to find out if there are specific national (local) standards for GFP in the several countries involved.

**GENERAL REMARK:** for the sake of better interpretation of the graphics the items as "Blank", "Not applicable", "Did not Answer", "Answer does not match the subject asked" and alike that are not relevant to every survey in screen will not be shown in the graphic, but they will be clearly indicated either below the graphic or on the corresponding tables.

**D 1.1.1-**

1.1.1) If yes, which standards are these?

We got answers from the following countries telling that they have Standards in their countries giving the corresponding names:

- Canada**
- China**
- Macedonia**
- Mexico**
- Poland**
- Russia**

**Switzerland  
USA**

NOTE: Mexican companies answered twice and one company answered “Non local Standards” thus the number of countries that confirmed to have own Standards is 8 (eight) among the 20 participant countries. To give an example of the information received we reproduce the comment received from the Canadian User coded EMP032: “*National Fire Protection Association NFPA 850 and 851), Manitoba Hydro Fire Manual, Factory Mutual Loss Data Sheets, & Best Industry Practices. First of all Factory Mutual Global is our Corporate insurer. A member of FM Global also serves on the NFPA 850, 851, and 853 Committees. Therefore, I have direct and indirect affiliation with the FM Global. In Canada, the National Fire Code references back to the NFPA Codes and Standards and therefore, they are regarded as mandatory. We follow these NFPA Codes and Standards very diligently, unless otherwise, over ruled by an Authority Having Jurisdiction (AHJ).*” On the other hand in Macedonia the User coded EMP027 explains the following: “*Standard JUS accepted by R. Macedonia after the split from former Yugoslavia to separated Republics, now this is a national Macedonian Standard.*”

The complete answers can be seen in the corresponding annex.

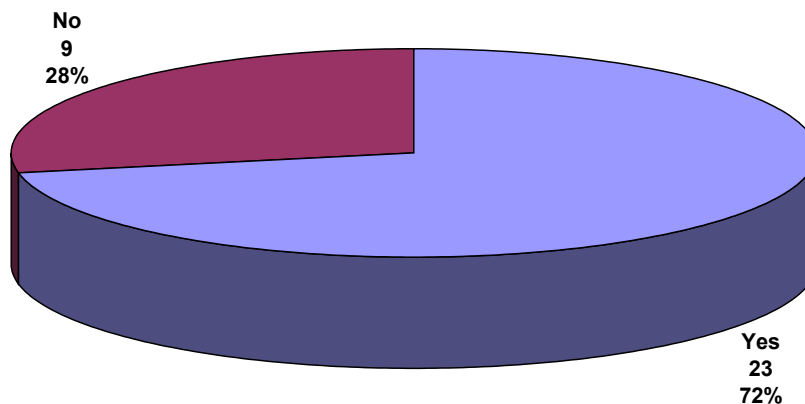
**D 1.2 -**

1.2) Do you recommend or install generator fire protection?

- Yes    - No

This is the basic question about the recommendation of the installation of Generator Fire Protection, starting with the direct YES or NO question resulted for this group in the following graphic:

**1.2 - Do you recommend or install generator fire protection?**



This survey has 1 Blank answer – not considered in the graph.

This results were complemented with the question below.

**D 1.2.1 -**

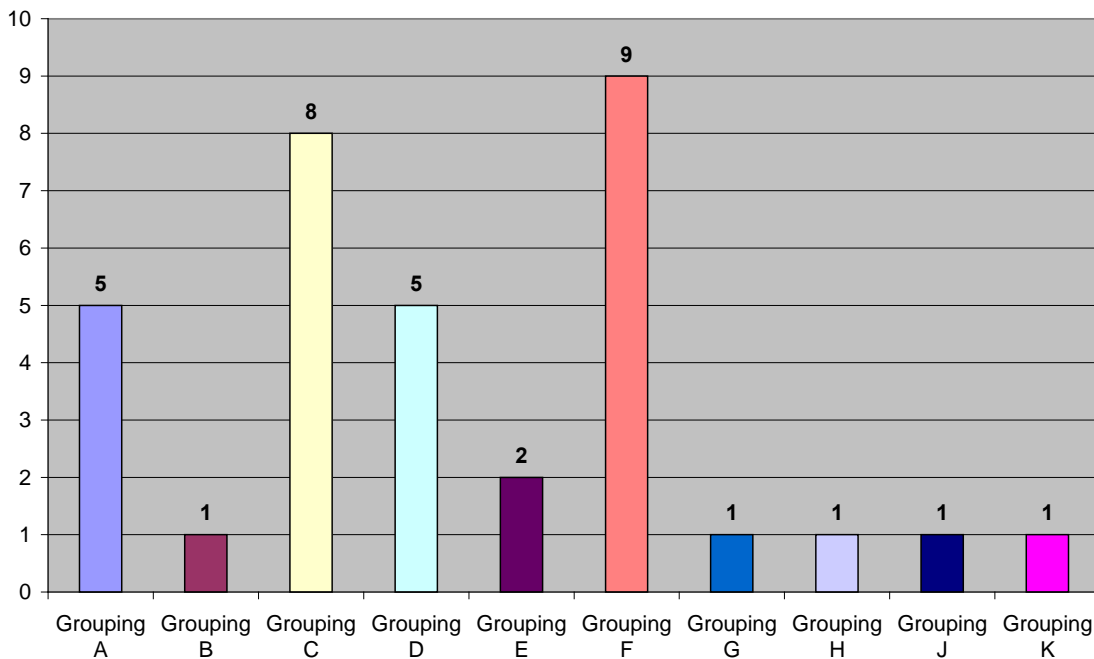
1.2.1) What are the reasons for that?

This open control question was made to gather more data on this critical question and to draw any conclusion we will have to balance also the following answers' statistics.

As an open question allows we got several different answers which were classified in "Groupings" in order to allow a statistical survey on the answers tendency (from time to time we will remind that the original answers as well as the complete statistical tables of the items concerned herewith are available on the corresponding annexes).

**1.2.1) What are the reasons for that?**

Grouping	Legend	Quantity
Grouping A	Safety (and safety reasons)	5
Grouping B	By observed occurrences	1
Grouping C	Do not install	8
Grouping D	Protection	5
Grouping E	Insurance (company) requirement	2
Grouping F	Reduce or minimize damages	9
Grouping G	Safety and reduce damages	1
Grouping H	In process of removing GFP	1
Grouping I	Did not answer (not considered for the graphic)	1
Grouping J	Smaller than 10 MVA not; bigger yes	1
Grouping K	Only for asphalt and shellak insulation system otherwise not	1



If we analyze the Grouping C Do not install we see that 8 do not install but the Groupings A Safety (and safety reasons) +D Protection +F Reduce or minimize damages =19 do install thus keeping the consistency of the first question made. It is interesting to recall the Grouping F that mentioned "reduce or minimize damages" and this seems to be the key issue from the

User stand point, it means how to get the equipment on grid as soon as possible after an accident.

This is a crucial controversial question therefore some of the comments received are reproduced below (the complete set of comments can be seen on the corresponding annex):

Considering the Grouping **A** Safety (and safety reasons) the Mexican User coded EMP021 quoted the following: *“Safety and security of facilities and staff.”*

Considering the Grouping **B** By observed occurrences the Brazilian User coded EMP008 stated that: *“By observed occurrences around the world.”*

Considering the Grouping **C** Do not install the Brazilian User coded EMP013 explained the following: *Our company does not adopt GPF for the following reasons: 1) Current projects apply more heat resistant, self-extinguishing and fire retardant materials (class " F "); 2) The digital protections offer a fast detection of the of electromechanical and dielectric causes and eliminate them in a few cycles, besides the fact that they have redundancies and are; 3) The electric energy sources cut, main contributor in the heat generation and fire outbreaks, are instantaneous; 4) An inappropriate or unintended actuation of the “GFP” may cause long unavailability of the generating unit; 5) The construction of tight compartments for hydro generators; 6) Adoption of an adequate policy of operating and maintenance; and finally, 7) Since our foundation(1952) and having currently more than 50 production units in operation there is no record of fire within the compartment of a hydro generator.*

Considering the Grouping **D** Protection the Brazilian User coded EMP025 stated that: *“Generator protection in the event of severe electrical faults. Hazards minimization Personnel protection”*

Considering the Grouping **E** Insurance (company) requirement the Polish User coded EMP053 told the reason as being: *“Mainly due to that insurance company insists to do it rather than to reduce scope of damages.”*

Considering the Grouping **F** Reduce or minimize damages the User EMP033 from New Zealand stated that: *“Prevent major damage to generators, minimize risks to personnel on site, and minimize risks of generator fire spread to other parts of the powerhouse. Appropriately designed and maintained generator fire protection systems are a good "insurance policy" to minimize fire damage to generators, and to ensure quick turnaround from a fire condition to return to generating service in as short a possible time. Without generating fire protection systems we would find ourselves at increased risk of fire damage, and also an increased risk of generator unit downtime due to fire damage. This is not a position we want to be in, and we see generator fire protection systems as a good risk mitigation measure.”*

Considering the Grouping **G** the Safety and reduce damages Chinese User coded EMP021 quoted the following: *“To guarantee the generator operation in reliability and safety as well as to decrease and shorten the extinction and duration of short circuit accident to a minimum.”*

Considering the Grouping **H** In process of removing GFP the Spanish User coded EMP023 stated that: *“Nowadays, fire protection systems are being removed with the programmed rewinding processes of the generators, and it is recommended fireproof insulations.”*

Considering the Grouping **J** Smaller than 10 MVA not; bigger yes the Macedonian User coded EMP027 stated that: *“Fire protection is not necessary for power of generator less than 10 MVA. For the power of generator more than 10 MVA fire protection is recommended by actual standards. According our long period of operation (more than 50 years) and experience with 9 generators, this obligation from the standard should be discussed.”*

Considering the Grouping **K** Only for asphalt and shellak insulation system otherwise not the Swedish User coded EMP047 stated that: *“We only use fire protection on asphalt and schellak insulation system. We don use fire protection on generator windings with epoxy insulation systems.”*

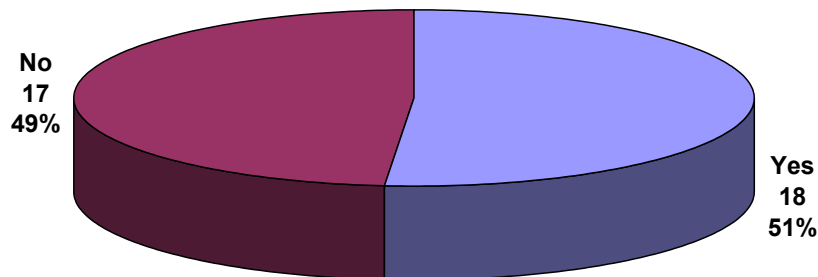
**D 1.3 -**

1.3) Is there any difference between the present and past fire protection strategies on generators in your organisation?

- Yes  - No

Recalling a question made in the original work made in 1981 about “Difference between the present and the past fire protection strategies” we had the opportunity to collect closed answers from this group as follows:

**1.3 - Is there any difference between the present and past fire protection strategies on generators in your organisation?**



In order to explore the present tendencies on this item two additional open type questions were made for the Users, the results are stated in the following items.

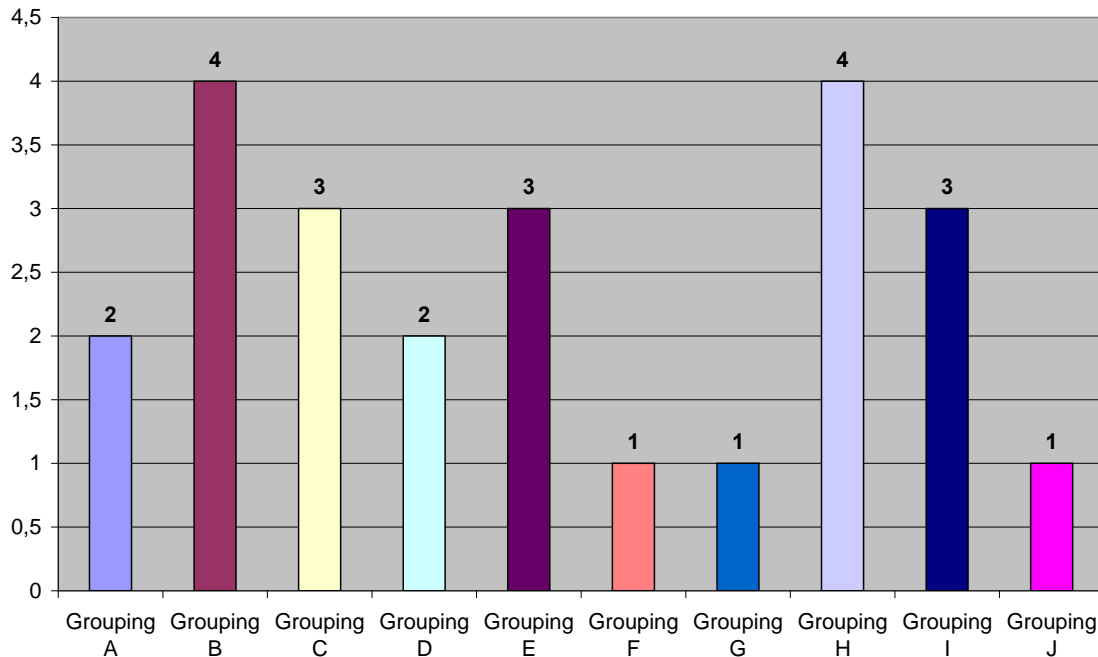
**D 1.3.1 -**

1.3.1) If your organization changed the protection strategy, what are the reasons for the change?

**1.3.1) If your organization changed the protection strategy, what are the reasons for the change?**

Grouping	Legend	Quantity
Grouping A	No Changes	2
Grouping B	Remove GFP with use of new insulation material	4
Grouping C	Implement water	3
Grouping D	To prevent unnecessary releases	2
Grouping E	To improve availability and effectiveness	3
Grouping F	Improvement in detection	1

Grouping G	Removing CO2	1
Grouping H	Changes depend upon insulation type	4
Grouping I	Focus on man security and environment	3
Grouping J	Changes will depend on GFP behavior	1
Grouping K	Not applicable (not considered for the graphic)	1
Grouping L	Did not answer (not considered for the graphic)	10



The Grouping H Changes depend upon insulation type calls for the dependency to the insulation type, the same criteria was mentioned by the Grouping B Remove GFP with use of new insulation material – here the question of “*non flammable*” insulation acts significantly but already calling for removal of the installed GFP and other significant groups call for the installation of GFP with water as extinguishing media, measures to improve availability and effectiveness and focus on man security and environment.

This is an important question that received many comments therefore some of them are reproduced below (the complete set of comments can be seen on the corresponding annex):

Considering the Grouping **A** No Changes the Brazilian User coded EMP045 quoted the following: “*Basically the organization uses the same strategy from the Eighties.*”

Considering the Grouping **B** Remove GFP with use of new insulation material the Austrian User coded EMP054 stated that they are: “*Removing CO2 fire fighting plants (hazard for staff), replacing flammable material by flame retardant and self extinguishing material, brazing of stator windings instead of soft soldering.*”

Considering the Grouping **C** Implement water the Australian User coded EMP039 explained the following: “*In the past we had CO2 protection on all our units. Moving from CO2 to water based protection on the basis of safety and effectiveness of existing CO2 systems. Now we are in the process of installing water based fire protection only on some generators based on risk analysis.*”

Considering the Grouping **D** To prevent unnecessary releases the Macedonian User coded EMP027 quoted the following: “*Many unnecessary activation of fire protection of generator.*”

Considering the Grouping **E** To improve availability and effectiveness the Mexican User coded EMP031 explained the following: “*Improve and upgrade existing CO2 and foam systems.*”

Considering the Grouping **F** Improvement in detection the Brazilian User coded EMP025 stated that: *“Our company's fire detection system is composed of thermal and smoke detectors. CO2 is discharged whenever a thermal detector and a smoke detector operate. A first change was introduced in order to allow the fire protection system operation in the event of severe faults which could cause the opening of the generator doors and hatches. In 1992, due to an explosion caused by a stator fault, the generator doors opened and their micro switches blocked the fire protection system operation. In order to allow the future operation of the fire protection system in the case of severe faults, the phase differential (87G) and turn-to-turn (87SP) protections were connected in parallel with the micro switches. A second change was introduced due to an improper operation of one generator fire protection system in 2007. The release of CO2 and the generator trip were caused by a thermal and a smoke detector incorrect operation. In order to prevent this kind of incorrect behavior, the fire protection system control panel output was connected in series with protections 87G and 87SP.”*

Considering the Grouping **G** Removing CO2 the Japanese User coded EMP028 quoted the following: *“For reducing the human damage in consideration, CO2 is no longer applied to the fire extinguishing system.”*

Considering the Grouping **H** Changes depend upon insulation type the Norwegian User coded EMP040 stated that: *“Change from bitumen based to modern epoxy or polyester based stator winding insulation.”*

Considering the Grouping **I** Focus on man security and environment the New Zealand User coded EMP033 explained the following: *“More focus on reducing fire risks to personnel, rather than focusing on the generating plant alone.”*

Considering the Grouping **J** Changes will depend on GFP behavior the Japanese User coded EMP043 stated that: *“We will change the protection strategy when we find the important defect on fire protection.”*

### D 1.3.2 -

1.3.2) Do you intend to change the existing generator fire protection strategy in future and if so please give the reasons.

This open type question was meant to explore the reasons those who may intend to make changes:

#### 1.3.2) Do you intend to change the existing generator fire protection strategy in future and if so please give the reasons.

Grouping	Legend	Quantity
Grouping A	No, no changes	20
Grouping B	Installing water + VESDA	1
Grouping C	Studying the elimination of GFP for small and medium units	1
Grouping D	Changing insulation and removing GFP	2
Grouping E	Depends of machine type	1
Grouping F	Removal of CO2	1
Grouping G	Not applicable	2
Grouping H	Formerly only equipment protection, nowadays personnel security, maintenance aspects, costs, new materials.	2
Grouping I	Did not answer	5

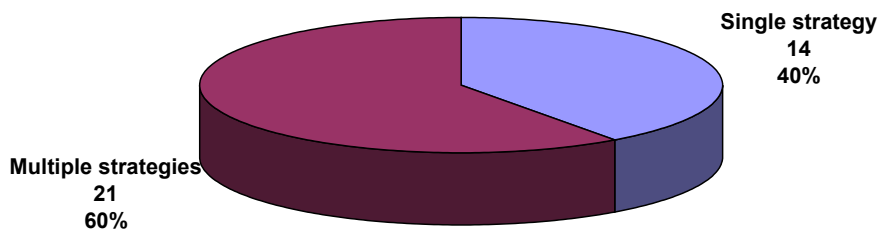
In this case the majority of answers did indicate that no changes are planned. But the Grouping C Studying the elimination of GFP for small and medium units shows what may be a tendency. Ans the Grouping B Installing water + VESDA mentions VESDA that is a sophisticated smoke detection system that now is appearing in Waterpower applications; it also shows another tendency that is the use of water.

**D 1.3.3 -**

1.3.3) Do you have a single generator fire protection strategy to cover all the generators or do you have different strategies to cover different generators based on various factors?  
Please tick the relevant box:  
 - Single strategy     - Multiple strategies

This item was first stated as a check-box question for which the following answers were received:

***1.3.3) Do you have a single generator fire protection strategy to cover all the generators or do you have different strategies to cover different generators based on various factors?***



**D 1.3.3.1 -** In order to survey this item deeper a series of correlated questions in form of check box with the request of a brief explanation note, the original text for this exploratory questions was:

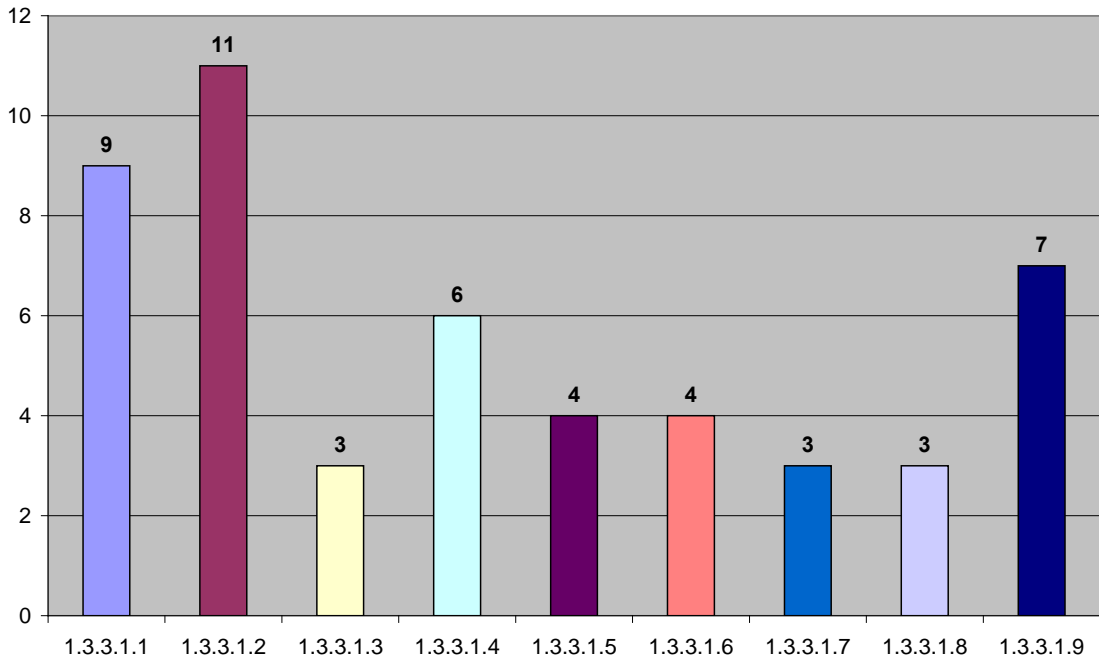
Original Questionairry's Question:  
1.3.3.1) If your organisation has multiple strategies to cover fire protection of different generators please tick and give brief explanation of the factors which contributed to use different strategies, as follows:

The following additional questions were made (here shown with the original numbering):

- 1.3.3.1.1) Generator Capacity (MVA)
- 1.3.3.1.2) Insulation Type (epoxy, polyester, bitumen etc)

1.3.3.1.3) Insulation Temperature Class (Class B, Class F etc)
1.3.3.1.4) Location (remote, underground, surface etc)
1.3.3.1.5) Cooling media (air, windings water cooled, etc)
1.3.3.1.6) Winding design features (roebel, multiturn, soft solder joints etc)
1.3.3.1.7) Generator Age
1.3.3.1.8) Contamination (carbon dust, oil vapor etc)
1.3.3.1.9) Other factors

The result of the check box questions was the following:



In this analysis we got 16 contributors that answered that these questions are not applicable (NA) to them either because they have only one GFP strategy or because they do not have GFP installed at all.

From the graphic above we can see that the most indicated reason for having multiple strategies is “insulation type” followed by “other factors” and “location”.

The contributions to this item are very reach in details, showing a high degree of collaboration will, and a separate analysis of each one of them show the following results. For this study the items, for which a significant amount of additional explanatins were given, were studied by means of a categorization of related explanations that allowed the issue of graphics (the original texts of the additional explanationa can be seen in the corresponding annexes).

**D 1.3.3.1.1 -**

Original Questionnaire's Question:
1.3.3.1.1) Generator Capacity (MVA) <input type="checkbox"/> - Yes <input type="checkbox"/> - No
Brief explanation note:

The check box question gave the following result: Yes = 9

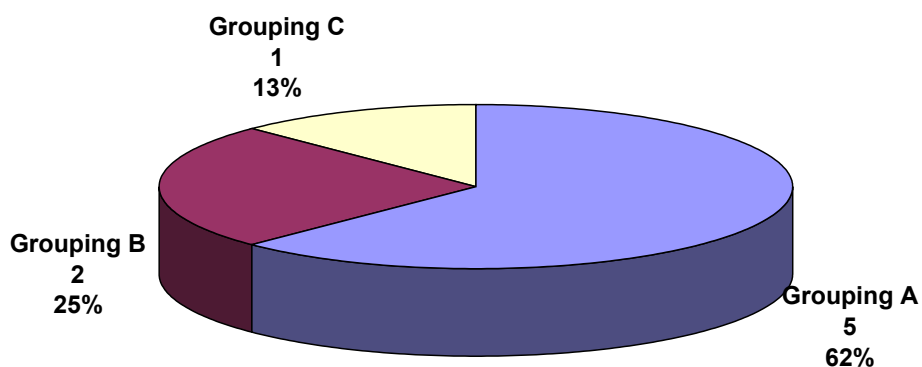
Here the “Yes” value is significative to the analysis. In principle the quantity of consistent open type answers should be limited in this case to 9, but some Users contributed even it they did not mark the corresponding check-box type question. The “additional” explanation is interesting for the gathering of experience. This explanation is valid for the next question until D-1.3.3.1.9

Open question analysis results (brief explanation note):

For this question the given additional explanations could be categorized as follows:

<b>1.3.3.1.1) Generator Capacity (MVA) Brief explanation note:</b>		
Grouping A	Consider a minimum power limit to install GFP	5
Grouping B	Consider if it is an open unit (not applied) or a closed (apply)	2
Grouping C	Considering A+B	1
Grouping D	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of answered questions</b>		<b>10</b>

**1.3.3.1.1) Generator Capacity (MVA) Brief explanation note**



The majority of additional explanations on this item point to the consideration of a minimum generator capacity as parameter for the decision of installing GFP. An example of the comments given to this item was the comment of the Brazilian User coded EMP016: “*Low capacity machines, with open air ventilation, have no fire protection system installed.*” Please refer to the corresponding annexes for the other comments.

**D 1.3.3.1.2 -**

1.3.3.1.2) Insulation Type (epoxy, polyester, bitumen etc) <input type="checkbox"/> - Yes <input type="checkbox"/> - No Brief explanation note:
--

The check box question gave the following result: Yes = 11.

Thus for 11 Users the decision to the type of insulation was the reason for having multiple strategies, this may happen with an User that has generators with bitumen with CO<sub>2</sub> GFP and generators with epoxy where the GFP's media is water, for instance.

Open question analysis results (brief explanation note):

For this question the given additional explanations could be categorized as follows:

<b>1.3.3.1.2) Insulation Type (epoxy, polyester, bitumen etc). Brief explanation note:</b>		
Grouping A	With epoxy insulation no GFP	1
Grouping B	Do not consider that likelihood or consequences of fire greatly increased by type of ground insulation material	1
Grouping C	With bitumen insulation is mandatory	1
Grouping D	Consider both A+C	3
Grouping E	Answer does not match the subject asked	2
<b>Total of answered questions</b>		<b>8</b>

The analysis here shows that the Category D With epoxy insulation no GFP + With bitumen insulation (GFP) is mandatory was the most indicated. As an example of the additional explanations given for this item by the Swedish User coded EMP047: *“No protection on Epoxy class F, after a fault the unit will trip. On asphalt and schellak windings class B there will be a fire detection system and depending on the relay protection system some will have CO<sub>2</sub> protection (most of the units have CO<sub>2</sub>) and some will go to stop.”* The others can be seen on the corresponding annex.

#### **D 1.3.3.1.3 -**

1.3.3.1.3) Insulation Temperature Class (Class B, Class F etc)  - Yes  - No

Brief explanation note:

The check box question gave the following result: Yes = 5

Open question analysis results (brief explanation note):

In this item only two comments were given and no categorization was necessary. We reproduce one of the comments in this case given by the Australian User coded EMP039: *“We do not consider that likelihood of fire or consequences greatly increased by type of insulation temperature class or operating temperature.”*

#### **D 1.3.3.1.4 - Location (remote, underground, surface etc):**

Original Questionnaire's Question:

1.3.3.1.4) Location (remote, underground, surface etc)  - Yes  - No

Brief explanation note:

The check box question gave the following result: Yes = 6

Open question analysis results (brief explanation note):

Although five additional comments were given (one check box got no comment) they were different one from each other not allowing a categorization to be made. We reproduce the comment given by the New Zealand User coded EMP033: *“The risks of a generator fire to personnel have higher consequences in underground power stations compared to surface power stations. We undertake a risk assessment to determine emergency egress times for personnel which is an input into deciding whether the generator fire protection system should employ a clean agent gas to minimize risks to personnel, or whether a CO2 system would be adequate.”* For the others please refer to the corresponding annex.

**D 1.3.3.1.5 -**

1.3.3.1.5) Cooling media (air, windings water cooled, etc)  - Yes  - No

Brief explanation note:

The check box question gave the following result: Yes = 4

Open question analysis results (brief explanation note):

Although only four checked “yes” there are six comments. The explanation for that is that one company indicated that has single strategy on the question 1.3.3 and decided to give a comment (in fact this was not necessary). Other two in spite of having answered “no” in the check box part decided to state a comment. Similar situations occurred in other questions.

There were too little different alternatives among the received additional comments and four informed to have only air-cooled generators. One of the comments is the following given by the German User coded EMP048: *“Only air cooled generators in operation in our business unit.”*

**D 1.3.3.1.6 -**

1.3.3.1.6) Winding design features (roebel, multiturn, soft solder joints etc)  -Yes  -

No Brief explanation note:

The check box question gave the following result: Yes = 4

Open question analysis results (brief explanation note):

Also in this question there were few additional answers and in this case two alternatives, each one with two answers. These alternatives refer to soft soldered joints and Roebel bars respectively.

**D 1.3.3.1.7 -**

1.3.3.1.7) Generator Age  - Yes  - No

Brief explanation note:

The check box question gave the following result: Yes = 3

Open question analysis results (brief explanation note):

This question received four comments. One of the companies although answered “no” decided to state a comment. These alternatives can be seen on the corresponding annex. The answers relay on the age of the winding, its conditions, and the following given by the Australian User coded EMP039 opposed to the others: *“We do not consider that likelihood of fire or consequences greatly increased by type of age as most of our generators falls into 30-50 year bracket.”*

**D 1.3.3.1.8 -**

1.3.3.1.8) Contamination (carbon dust, oil vapor etc)  - Yes  - No

Brief explanation note:

The check box question gave the following result: Yes = 3

Open question analysis results (brief explanation note):

This item got two comments, one of them given by the Mexican User coded EMP031 refer to *“carbon dust and oil vapor”*.

**D 1.3.3.1.9 -**

1.3.3.1.9) Other factors  - Yes  - No

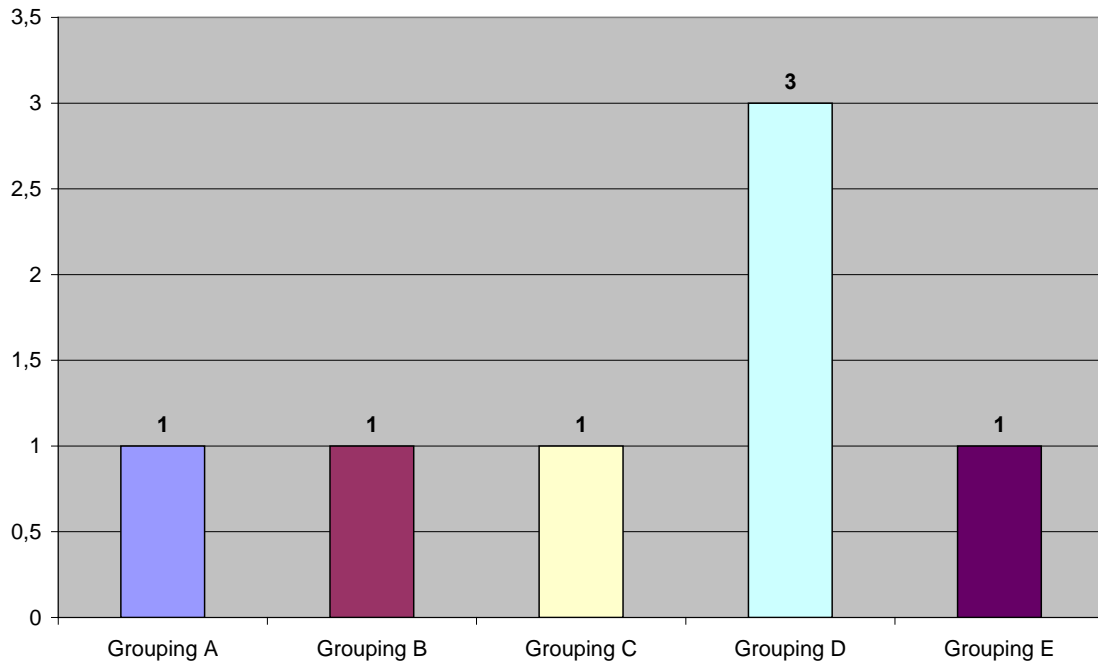
Please specify these other factors and give a brief explanation note:

The check box question gave the following result: Yes = 7

Open question analysis results (brief explanation note):

For this question eight additional comments were given and the result of the categorization is the following:

<b>1.3.3.1.9) Other factors. Please specify these other factors and give a brief explanation note:</b>		
Grouping A	Influence of bearing and if horizontal / vertical generator	1
Grouping B	Attention to business consequences of Loss	1
Grouping C	Depends on Early warning detection or conventional detection	1
Grouping D	Electrical system and relay protection. redundancy, quality, fast relay etc.	3
Grouping E	High humidity	1
Grouping F	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of answered questions</b>		<b>8</b>



New aspects were added to those that were indicated in the alternatives 1 to 8, as shown in the categories above.

One example of the category “D” Electrical system and relay protection. redundancy, quality, fast relay etc. is the additional comment given by the Brazilian User coded EMP020: *“The fire extinguishing method is one: through the CO2 application. However, there are different forms to deploy the discharge of the gas, which varies in function of the time in which the plant was constructed or even of the manufacturer of the machine. Basically, the application methods are the following ones: 1) The CO2 discharge and the machine stopping is triggered by the actuation of any one of these relays: 87G (differential) or 49C (thermostat); or 2) The CO2 discharge and the machine stopping is triggered by the actuation of the logic: 87G+ smoke detector or 87G+ temperature detector.”*

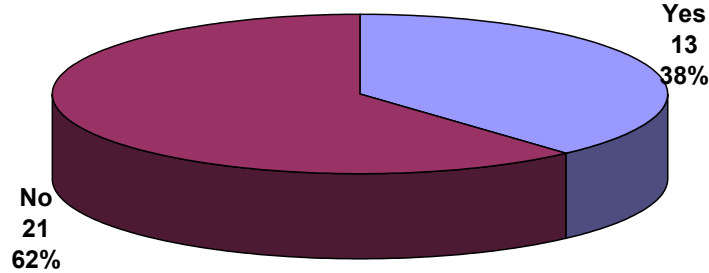
**D 1.4 -**

1.4) Is there any requirement for the installation of generator fire protection made by a third party, for instance your insurance company or any authority having jurisdiction?  
 - Yes    - No

This question and the following three intend to survey if there are other reasons to install GFP other than an internal safety policy of the company; and if there is an internal work aiming cost reductions related to the GFP application.

The first part is a check box question that resulted in the following ratings:

**1.4) Is there any requirement for the installation of generator fire protection made by a third party, for instance your insurance company or any authority having jurisdiction?**



This survey has 1 Blank answer – not considered in the graph.

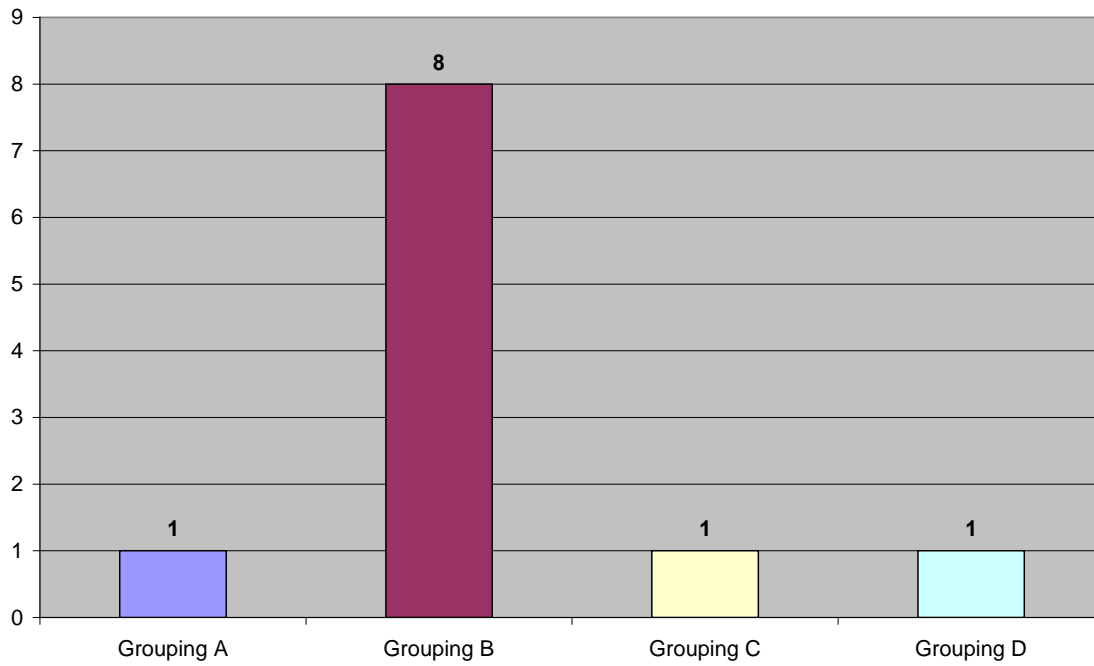
This step of the question shows that for the majority of the companies there is no requirement for the installation of GFP stated by a third party.

**D 1.4.1 -**

1.4.1) If yes, is there any specific generator fire protection type recommended? Please specify.

This is a pure open question with a possibility to get 13 answers at most.

<b>1.4.1) If yes, is there any specific generator fire protection type recommended? Please specify.</b>		
Grouping A	CO <sub>2</sub>	1
Grouping B	No, no specific system is recommended by a third party	8
Grouping C	Water is recommended by the insurer	1
Grouping D	Several systems are recommended	1
Grouping E	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of answered questions</b>		<b>13</b>



In most of the cases when GFP is required by a third party there is no specific system required.

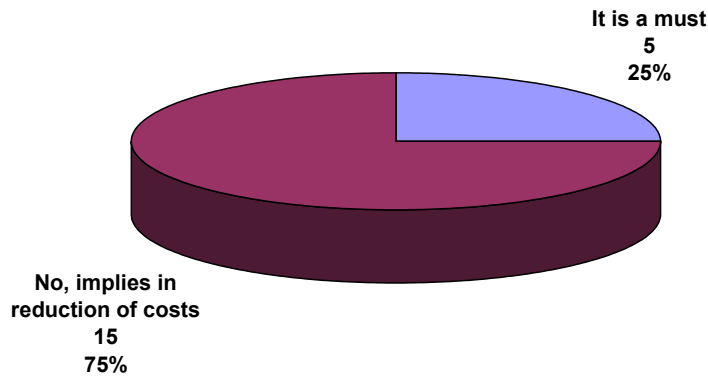
Note: In some cases the answers given do not match the subject asked and this was taken as a “grouping”; in this particular case the “E”- present in the table but not considered in the graphic.

**D 1.4.2 -**

1.4.2) Is this a must or does it imply in reduction of insurance costs?  
 - It is a must     - No, in fact it implies in reduction of insurance costs  
 Please comment:

Here the question was stated giving two alternatives that got the following rating:

**1.4.2) Is this a must or does it imply in reduction of insurance costs?**

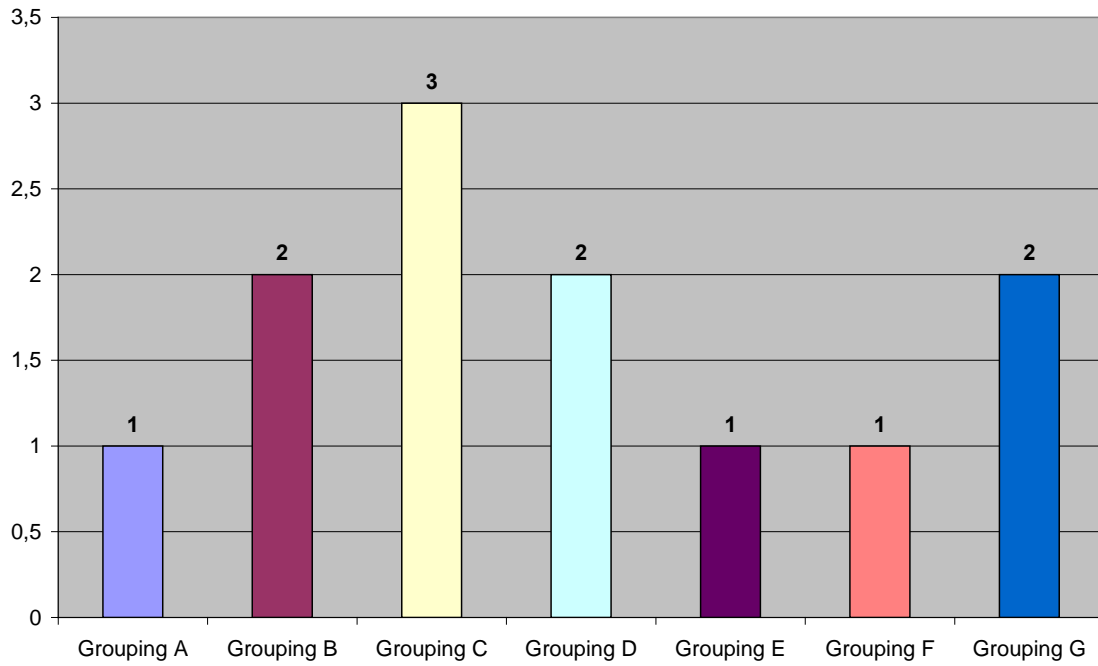


This survey has 15 Blank answers – not considered in the graph.

Open question analysis results (please comment):

In order to profit from the contributors experience a request for comments was stated with the following open question result:

<b>1.4.2) Is this a must or does it imply in reduction of insurance costs? Please comment:</b>		
Grouping A	Does not use and justifies towards the authorities and insurance company	1
Grouping B	Installation of GFP is regulated by the authorities in charge, or is regulated by Law	2
Grouping C	Implies in an insurance premium reduction	3
Grouping D	Simplifies the process of getting money from the insurer should an accident occur; or makes it easier to get a coverage	2
Grouping E	Is requested by the insurance company	1
Grouping F	There is no specific requirement	1
Grouping G	Does not imply in insurance premium reduction; but may be recommended	2
Grouping H	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of answered questions</b>		<b>13</b>



The answers show the tendency in each company and the Grouping C was more selected and an example of the complete answers received (this one given by the Brazilian User coded EMP045) that can be seen in the annex is the following: *“Our strategy is to use generator fire protection for all the machines. Recently this strategy contributed for a reduction of costs in the contracts with the insurance company for all our power plants.”*

#### D 1.4.3 -

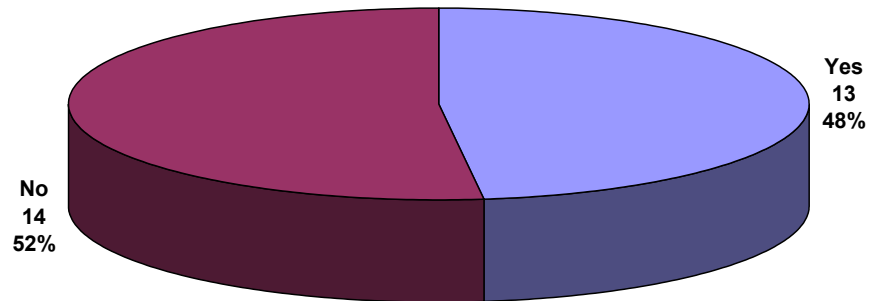
1.4.3) Is there a joint work between the technical department and the department responsible for the insurance of the plant (s) considering the cost reductions that may be achieved by reducing the risk by means of appropriate fire protection methods?

- Yes  - No

Please comment if applicable:

This item started with a check box question that gave the following result:

**1.4.3) Is there a joint work between the technical department and the department responsible for the insurance of the plant (s)?**



This survey has 8 Blank answers – not considered in the graph.

Open question analysis results (please comment if applicable):

An almost even result was obtained and in this case the requested additional comments may help to understand the situation inside the companies involved.

<b>1.4.3) Is there a joint work between the technical department and the department responsible for the insurance of the plant (s) considering the cost reductions that may be achieved by reducing the risk by means of appropriate fire protection methods? Please comment if applicable:</b>		
Grouping A	Confirmed the cooperation work aiming price reduction	3
Grouping B	Confirmed that there is NO cooperation work aiming price reduction	1
Grouping C	Answer shows a misunderstanding of the question	3
Grouping D	Answer does not match the subject asked	3
<b>Total of answered questions</b>		<b>10</b>

Ten additional comments were received in this case and the analysis of the same showed that six of them did not correspond to what was asked; either because the aspect of cost reductions did not occur or because the explanations really did not focus the requested information. From the remaining answers three confirmed that an internal cooperation exists. One of these additional explanations is the following: “(The check box question was answered with ‘Yes’) the joint work, was carried through in order to reduce the costs of the insurance using level risks parameters”

As an example of answer that did not match, at least entirely, the asked condition was: “(The check box question was answered with ‘Yes’) but no direct reduction in insurance premiums to justify fire protection”. The complete answers can be seen in the annex.

This analysis did show that in some companies there is a joint work aiming the use of internal synergy in order to reduce costs by the application of GFP following the procedure requested by the insurers this resulting in costs reduction.

D 1.5 -

1.5) Did you have fire in any of your generators in not least than the last 20 years?

- Yes  - No

If yes, how many?

This is a very important part of this work because it shows the real experience on occurred accidents in generators. In fact the question stated was specific recalling the occurrence of **FIRE** in generators. From the standpoint of the responsible Convener the answers were taken as received, although a discussion about the definition of what has to be considered as fire was raised during the elaboration of the work.

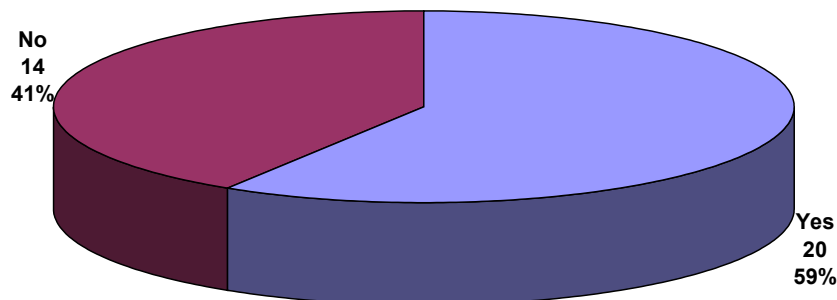
One definition of what should be considered fire in a generator when we look at the need for fire suppression systems would be "*burning that is sustained once the ignition source is removed*". But there are many surrounding conditions to be evaluated though...

In this respect an important contribution offered by one knowledgeable expert from the USA calls for the following consideration: "*As one can recognize, the oxygen and heat are present if no suppression is available. The question then becomes whether or not the fuel exists to support a chemical reaction – according to the Fire scheme. Manufacturers suggest that the current materials (epoxy based materials) will not burn if the heat is removed.*

*However, many times the heat is so intense that even if the "flash" that started the ignition is removed, the epoxy forms combustible gas (in the contained environment of the air housing) via a chemical reaction, and it becomes the fuel source."*

The result of the check box question of the item 1.5. was the following:

**1.5) Did you have fire in any of your generators in not least than the last 20 years?**



This survey has 1 Blank answer – not considered in the graph.

Open question analysis results (if yes, how many?):

The answer for the question "**if yes, how many?**" resulted in **64** generators indicated by the 20 companies. Quantity equalization with the question 1.5.5.1 was made and some information given in this item was corrected considering the information given in the tables for more than one generator – "Form for multiple machines". Generally only the number of

units was indicated but some additional comments were given and can be seen in the corresponding annex.

**D 1.5.1 -**

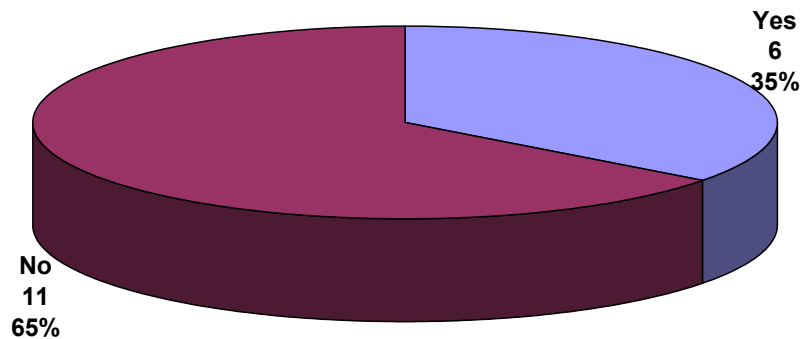
1.5.1) Did they occur on the same type of generator?

- Yes  - No

Please comment:

The check box question of this item resulted in the following information:

**1.5.1) Did they occur on the same type of generator?**



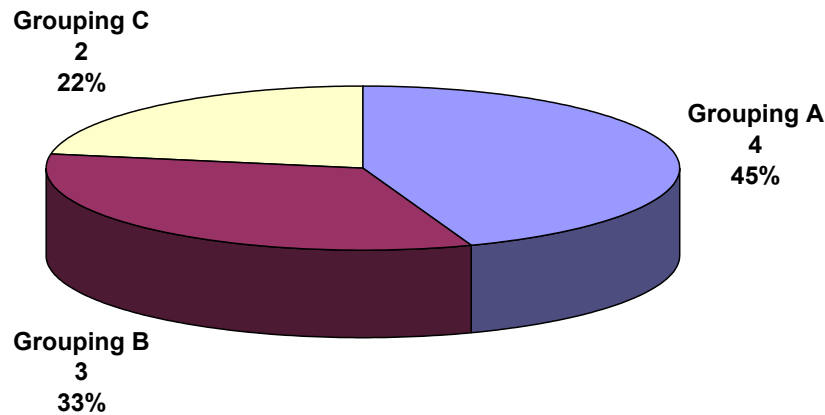
This survey has 18 Blank answers – not considered in the graph.

Open question analysis results (please comment):

The survey of the received additional comments made with the corresponding categorization showed the following result:

<b>1.5.1) Did they occur on the same type of generator? Please comment:</b>		
Grouping A	Different type of machines	4
Grouping B	Similar type of machines	3
Grouping C	Only one accident to report	2
Grouping D	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of answered questions</b>		<b>11</b>

**1.5.1) Did they occur on the same type of generator? Please comment:**



This survey has 2 “Answer does not match the subject asked” answers – not considered in the graph.

The categorization shows the distribution of the comments given for different generators type – Grouping A (comment example: “*Both machines and causes were different, but they evolve to fire.*”) and equal type of generators – Grouping B (comment example: “*The fires occurred on the same 2 unit power station, the generators are of identical design.*”). For more comments please refer to the annex.

**D 1.5.1.1 -**

1.5.1.1) What was the reason for the fire to start? Please tick the relevant box indicating the trigger factor. If you have experienced more than one fire in not least than the last 20 years (\*) please copy the following table and fill it for each separate fire occurrence (please indicate the corresponding fire years).

The work made with a questionnaire imposes some limitations on the indication of more than one example; (\*) in order to give more freedom for the indication of multiple examples an additional table was issued (*Form for multiple machines*). The results below show the compilation of the contributions given on the original questionnaire plus those given in the additional tables. A special compilation table was issued to get the consolidated results given bellow. This table passed to be the source for the comments to the items below. This consolidated results allowed also for a deep analysis of the given additional explanations considering their consistency towards the indicated examples. The additional explanations should address these examples to be consistent with the survey.

The time limit for this part of the fire examples survey was also discussed; there are many different situations considering the size of the involved companies. For a company that has a great quantity of generating stations and hundreds of generating units the survey work becomes a difficult task if the time frame would look far in the past – therefore a time frame of 20 years initially defined. On the other hand other companies have examples that fall over this limit, it means that are older than 20 years. Being so the time frame was defined

as “at least 20 years” (but not limited to) and all examples were accepted in spite of their age.

For this item a special compilation table was made including the detailed questions; and the analysis of the corresponding check box questions resulted as follows:

Detailed question	Answers “Yes”
1.5.1.1.1) Electrical Fault in the stator winding	39
1.5.1.1.2) Electrical fault in the rotor winding	8
1.5.1.1.3) Electrical fault in the exciter housing	2
1.5.1.1.4) Mechanical Fault in bearings	5
1.5.1.1.5) Other Mechanical faults	4
1.5.1.1.6) Any other?	6

The great majority of reported accidents were caused by “Electrical faults in the Stator Windings”. Additional explanations were given to each detailed question; being so some of them are shown below. Not all received comments did allow an analysis by categorization, but the original issues of the given comments may be seen on the annex. All they complement the question: “What was the reason for the fire to start?”

**D 1.5.1.1.1 -**

1.5.1.1.1) Electrical Fault in the stator winding <input type="checkbox"/> - Yes <input type="checkbox"/> - No Additional information:
---

After the consideration of the information received with the “form for multiple machines” the check box questions analysis of the original questionnaire is superseded. The results of the statistic of the item 1.5.1.1 become the valid ones. This consideration applies to the next items up to the item 1.5.1.1.6.

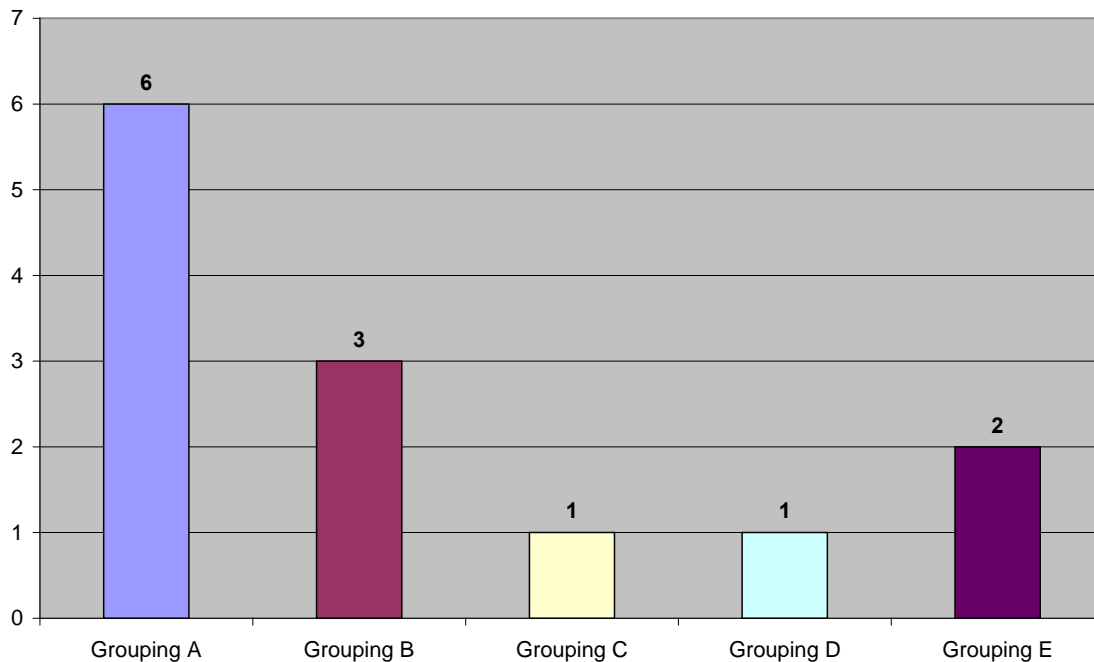
Closed questions result (check-box): from the 64 reported accidents 39 were caused by electric fault in the stator winding.

Open question analysis results (additional information):

The question 1.5.1 indicated that 20 companies informed that they had fire in generators. Many of them gave information for multiple accidents in their power plants. In this case we got 13 additional information and in 26 cases an additional explanation was not indicated, these later are not interesting for the present study.

All given additional information after the proper consistency screening was made were consolidated in the table 1.5.1.1 and then transposed back to this item to profit from the information received.

<b>1.5.1.1.1) Electrical Fault in the stator winding. Additional information:</b>		
Grouping A	Phase to phase faults	6
Grouping B	Phase to ground faults	3
Grouping C	Isolation breakdown-did not specify fault type	1
Grouping D	Failure in flexible connection	1
Grouping E	Failure in soft soldering	2
Grouping F	(Answer does not match the subject asked) - Not indicated (not considered for the graphic)	26
<b>Total of answered questions</b>		<b>35</b>



The phase to phase faults are more frequent according to the table above. Here one example of the received additional comments: *“All fires have been the results of defects that have developed into phase to phase faults (lot of energy able to be feed into fault). Never seen a fire result from a straight earth fault.”*

**D 1.5.1.1.2 -**

1.5.1.1.2) Electrical fault in the rotor winding  - Yes  - No

Additional information:

Closed questions result (check-box): from the 64 reported accidents 08 were caused by electric fault in the rotor winding.

Open question analysis results (additional information):

The 02 consistent answers received on the original questionnaire did not allow a categorized survey, but two of these additional information recalled for: *“burnt flexible connection”*.

As already explained in order for the given additional information to be consistent they have to address to a corresponding item of one correspondent given example. The additional information that did not fulfil this condition could not be taken in to consideration. As one example of such non considered additional information we can mention the following one given by the company from New Zealand coded as EMP015: *“Have seen a pole to pole connection vaporize and while there was considerable arc splatter there was no fire”*. Anyhow this is an interesting contribution though.

#### D 1.5.1.1.3 -

1.5.1.1.3) Electrical fault in the exciter housing  - Yes  - No

Additional information:

Closed questions result (check-box): from the 64 reported accidents 02 were caused by electric fault in the rotor winding.

Open question analysis results (additional information):

In this case one consistent additional explanation was given, and it was the following: *“Unit had CO2 generator fire suppression which did not cover the exciter housing directly. CO2 was not released and when fault was cleared fire went out.”*

Also in this case there were additional information that could not be considered due to lack of consistency, it means they were not indicated in the corresponding check box question. We reproduce them for record purposes. The first was given by the company from New Zealand coded as EMP015: *“Have seen a couple of slipping catherine wheels (the traditional name for a spinning firework) as the result of carbon brush failures but no fire as the result”*. The other came also from New Zealand, company coded as EMP033 and call for: *“Excitation connections to the generator failed causing the leads to ‘flap’ free and shear off a large proportion of the end windings resulting in a generator fire.”*

#### D 1.5.1.1.4 -

1.5.1.1.4) Mechanical Fault in bearings  - Yes  - No

Additional information:

Closed questions result (check-box): from the 64 reported accidents 05 were caused by Mechanical Fault in bearings.

Open question analysis results (additional information):

The 03 consistent answers received did not allow a categorized survey, but one of these additional information, Given by a Mexican company coded as EMP012, recalled for: *“Failure on the bearing cooling system, causing the stator to be wet which caused a fault between phases..”*; which in fact resulted in a consequential winding problem.

In this particular case we have an interesting example given by a Brazilian company coded as EMP58 that inserted one comment to each detailed item, but all of them were interconnected and deflagrated by the following situation: *“All those damages has began after oil circulation failure of the turbine thrust bearing. The main circuit breaker hasn’t opened after relay’s high temperature metal operation.”* Since the starting point is the relevant one for this analysis the others could not be considered.

**D 1.5.1.1.5 -**

1.5.1.1.5) Other Mechanical faults  - Yes  - No

Additional information:

Closed questions result (check-box): from the 64 reported accidents 04 were caused by Other Mechanical faults.

Open question analysis results (additional information):

The 04 consistent answers received did not allow a categorized survey, but one of these additional information recalled for: *“An item of steel was left behind in the generator enclosure following routine maintenance. The item caused an electrical fault in the stator, resulting in a generator fire.”* The others can be seen on the table 1.5.1.1.5 in the annex.

**D 1.5.1.1.6 -**

1.5.1.1.6) Any other?  - Yes  - No

Additional information:

Closed questions result (check-box): from the 64 reported accidents 06 were caused by “any other reason”.

Open question analysis results (additional information):

The 03 consistent answers received did not allow a categorized survey, but one of these additional information recalled for: *“Generator disconnect operation under load propagating fire inside the generator housing”*.

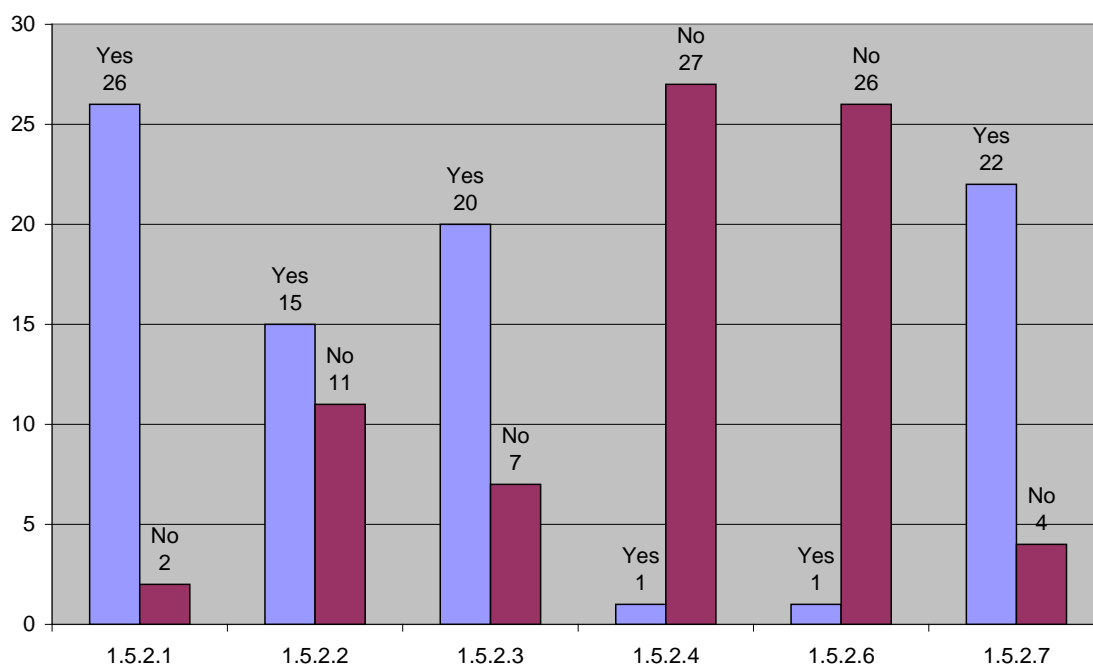
Also in this case there were additional information that could not be considered due to lack of consistency. We reproduce them for record purposes. The first was given by the company from Poland coded as EMP053: *“Broken mechanical parts”*. From the Macedonian company coded EMP027 we received: *“Generator 1: the insulation part of rotor pole was broken Generator 2: Mechanical part of bolt from lubrication system was broken and fall inside the generator during the testing of generator for start up after rehabilitation of lubrication system”*. From the Brazilian company EMP045 came: *“The attrition between electrically passive components of the rotor and the stator generated heat that evolved for fire (heat + smoke)”*. And finally from the Mexican company EMP012 we received: *“A machine switch failure caused circulating currents in the rotor; this increased the temperature and set fire to the fiberglass air deflection covers, causing a generator fire”*.

**D 1.5.2 -**

1.5.2) Please provide the following information on the units where fires occurred in not least than the last twenty years. If you have experienced more than one fire over the time your answer is covering, copy the following table and fill it for each separate fire occurrence (please specify the time span or the occurrence years).

Also for this question a special compilation table, including information given on the “form for multiple machines”, was issued in order to collect data and allow a comparative study of the detailed questions that are part of this item and the analysis of the corresponding check box questions resulted as follows:

Detailed question	Answer “Yes”	Answer “No”
1.5.2.1) Was the unit equipped with fire protection equipment?	26	2
1.5.2.2) Did the fire protection system work according to the design specification?	15	11
1.5.2.3) Was the fire extinguished solely by the installed generator fire protection system without any additional external help?	20	7
1.5.2.4) Did the fire spread outside the generator?	1	27
1.5.2.5) Give a brief description of the damage to the generator and surrounding:	open	question
1.5.2.6) Were there any direct or indirect fatalities as a result of the fire started in the generator?	1	26
1.5.2.7) Was the fire protection designed to trigger automatically in an event of a fire or/and heat detection?	22	4



This graph gives a good view of the proportion of each question involved in the item 1.5.2. The question 1.5.2.5 does not appear in the graphic because it is an open question that will be discussed below.

According to some time indication received it is possible to say that the reported fire accidents of the 64 generators did occur between 1980 and 2001.

These detailed questions are specific and the result of each one of them is stated below. The answers are basically those given on the original questionnaire added to the few information that were given by using the “form for multiple machines”.

The following questions are those that implied in additional information for the reported accidents (the others are pure check-box questions and their analysis is statistical), a brief comment to the check box questions was also issued:

**D 1.5.2.1 -**

1.5.2.1) Was the unit equipped with fire protection equipment?

- Yes  - No

If Yes, what is the extinguishing media? (Eg. CO<sub>2</sub>, water, etc). If the media is chemical, please give the name.

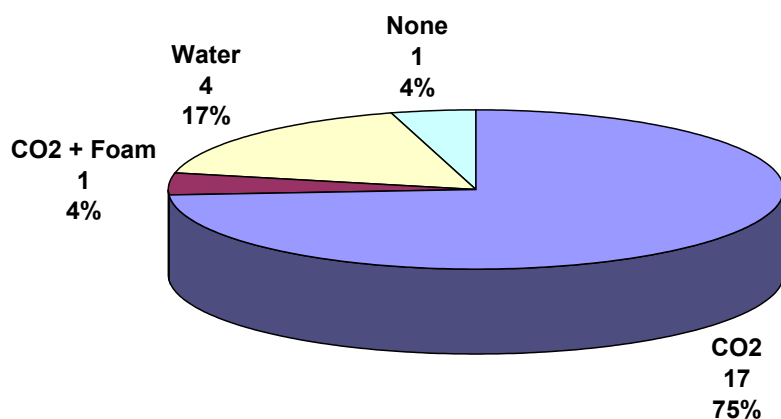
Closed questions result (check-box): as stated in the table above we had Yes= 26 and No= 02 thus giving a big majority of generator wit GFP installed.

Open question analysis results (if Yes, what is the extinguishing media?):

The additional information given, regarding the extinguishing media used by the installed GFP allowed the analysis with categorization, as follows:

1.5.2.1) Was the unit equipped with fire protection equipment? If Yes, what is the extinguishing media? (Eg. CO <sub>2</sub> , water, etc). If the media is chemical, please give the name.		
Grouping A	CO2	17
Grouping B	CO2 + Foam	1
Grouping C	Water	4
Grouping D	None	1
<b>Total of answered questions</b>		<b>18</b>

**1.5.2.1) Was the unit equipped with fire protection equipment? If Yes, what is the extinguishing media?**



This question's result is in line with other questions in this work and shows that among the companies that answered the questionnaire the majority uses CO<sub>2</sub> (Grouping A) as extinguishing media. This was true also for this question that pursued additional information of the reported fire accidents on generators.

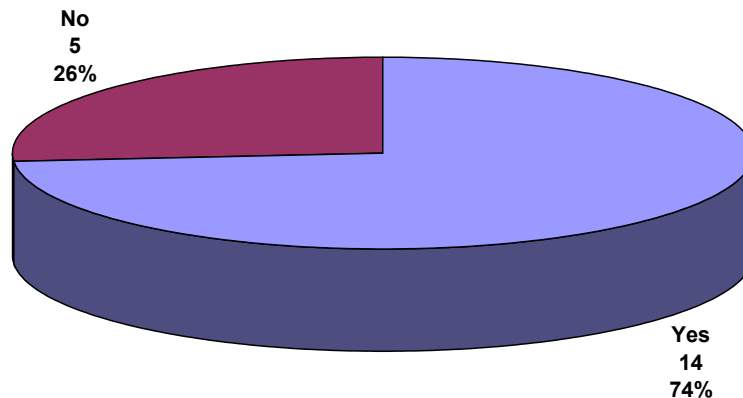
**D 1.5.2.2 -**

1.5.2.2) Did the fire protection system work according to the design specification?

- Yes  - No

Closed questions result (check-box): giving a big majority of generators wit GFP installed.

**1.5.2.2 - Did the fire protection system work according to the design specification?**



This survey has 16 Blank answers – not considered in the graph.

Brief comment:

This case shows a fairly high amount of answers telling that the fire protection system did not work according to the design specification (26%). The important conclusion in this case is that the reasons for this non-compliance shall be determined in order to improve the GFP reliability from case to case.

**D 1.5.2.3 -**

1.5.2.3) Was the fire extinguished solely by the installed generator fire protection system without any additional external help?

- Yes  - No

Closed questions result (check-box): as stated in the table above we had Yes= 20 and No= 07 thus giving a big majority of generators wit GFP installed.

Brief comment: in this case the majority of the fires were extinguished solely by the installed generator fire protection system without any additional external help. In 07 examples help from third sources was required.

Although no additional information was requested by this check-box question we got an statement given by the New Zealand's company coded as EMP015 that indicated "Yes" for the two given examples in this question (on the question before it was informed that the GFP did not work according to the design). The statement is: *"The generator fire protection did not really play any part in extinguishing of the fires. The fires basically self extinguished once the energy source was removed by the generator electrical protection relays and by the windage as the machine shut down. However the windage tends to drag the fire around the stator so damage is more extensive than if water could have been discharged"*

**D 1.5.2.4 -**

1.5.2.4) Did the fire spread outside the generator?

- Yes  - No

Closed questions result (check-box): as stated in the table above we had Yes= 01 and No= 27 thus giving a big majority of generators wit GFP installed.

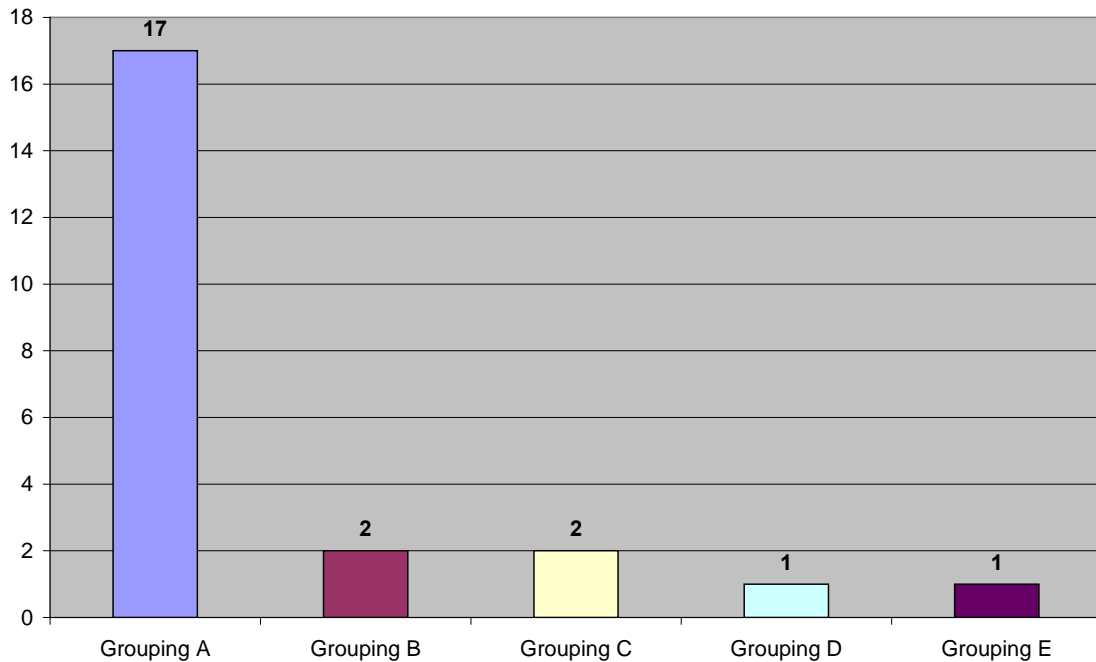
Brief comment: here we have a good result because only in one case the fire did the fire spread outside the generator. Such a spreading can involve other components of the power plant in to the fire leading to a major catastrophe.

**D 1.5.2.5 -**

1.5.2.5) Give a brief description of the damage to the generator and surrounding:

This is a pure open question and the contributions given with the "form for multiple machines" added new information to that received with the initial questionnaire. A new summary table was issued for this item which was taken for the categorization study that gave the result below:

<b>1.5.2.5) Electrical Fault in the stator winding. Additional information:</b>		
Grouping A	Stator winding damage	17
Grouping B	Excitation slip rings and/or brushes damage	2
Grouping C	Rotor and stator winding damage	2
Grouping D	Little damage but great cleaning works.	1
Grouping E	Fire remained contained inside the generator housing	1
Grouping F	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of additional information given</b>		<b>24</b>



The 17 additional information reaching 70,8% of the total that point to stator winding damage (Grouping A) show that this is the most critical part of the machine and deserves special attention when the GFP's design is made.

Very reach comments to this issue were given and some of these were selected to be reproduced as follows.

Grouping A: the contribution of the company from New Zealand coded EMP015: *"In all cases the fire was contained within the generator winding enclosure. The most recent case (7yrs ago) damage confined to a section of the bottom end winding - copper lost and fire damage to a little under a third of circumference. The next case (9yrs ago) there was significant copper lost and fire damage to the top end winding area of the machine, extending approx 1/2 way around the stator. Cases 3 and 4 (12 -14 yrs ago) there was some copper lost in phase lead and fire damage to approximately a third of the top end winding. Other experience is outside 20 year window."* For the sake of time identification this contribution was received in 2008.

Grouping B: here the contribution from the German company coded as EMP049, that reported the occurrence of: *"Contamination, damages of coal brushes."*

Grouping C: the Brazilian company coded as EMP058 reported the following: *"The rotor totally damaged and the stator partial damaged. The rotor was fixed definitively and the stator was partially fixed until it was possible to exchange it for a new one."*

Grouping D: the company from New Zealand coded EMP033 reported that: *"Damage was minimal, but required a significant clean up effort inside the generator enclosure."*

Grouping E: the Canadian company coded EMP036 about damage to the generator and surrounding" reported that: *"none - contained within enclosure"* (probably their focus remained on damages on the surroundings).

The complete set of additional information given also for the item 1.5.2.5 can be seen on the correspondent annex, as well as on the original questionnaires answers received.

**D 1.5.2.6 - Were there any direct or indirect fatalities as a result of the fire started in the generator?**

1.5.2.6) Were there any direct or indirect fatalities as a result of the fire started in the generator?

- Yes  - No

Closed questions result (check-box): as stated in the table above we had Yes= 01 and No= 26.

Brief comment: here we have a good result because only in one case fatality occurred. This indicates that the Users involved show a good degree of operational safety in their plants considering fire accidents.

**D 1.5.2.7 - Was the fire protection designed to trigger automatically in an event of a fire or/and heat detection?**

1.5.2.7) Was the fire protection designed to trigger automatically in an event of a fire or/and heat detection?

- Yes  - No

Closed questions result (check-box): as stated in the table above we had Yes= 22 and No= 04.

Brief comment: the question of GFP release method asked with this question was also discussed in other questions that go deeper in this operational definition. According to this first approach the majority of Users do have automatic release.

**D 1.6 -**

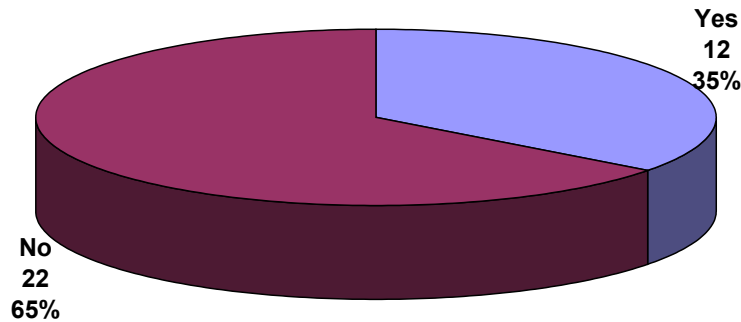
1.6) Do you have different types of fire protection systems within the generators installed in your power plants?

- Yes  - No

This question starts a survey that is complemented by the questions 1.6.1 to 1.6.4. The answer to the first part, 1.6, defined answers from the questions 1.6.1 and 1.6.2.

The answers for the question 1.6 showed the following results:

**1.6 - Do you have different types of fire protection systems within the generators installed in your power plants?**



This survey has 1 Blank answer – not considered in the graph.

The majority of the answers showed that the common practice is to have a single protection scheme, but when Users have generators of different generations of insulation (bitumen or epoxy based), or different type of location (open air or cavern) there are different types and sometimes it is a transition period.

**D 1.6.1 -**

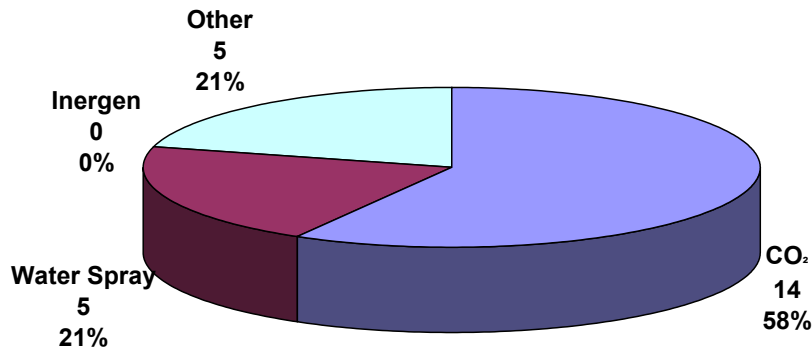
1.6.1) If no, please indicate which is your sole fire protection system:

- CO<sub>2</sub>
- Water Spray
- Inergen
- Other

If other please indicate here which:

This question was meant for those Users that have only one GFP system type. There was a choice between CO<sub>2</sub>, Water, Inergen (inert gas) or other, where other could be “no GFP installed”. The result was the following:

**1.6.1) If no, please indicate which is your sole fire protection system:**



This survey has 5 Blank answers – not considered in the graph.

Here the 49% of answers indicating the sole use of CO<sub>2</sub> is coherent with other questions showing the broad use of this extinguishing media.

Open question analysis results (If other please indicate here which):

But there is an open question related to “others”. This open question got the 05 possible answers but no categorized study was required in this case.

In the sequence some answers are reproduced. One User from Australia, coded as EMP039 informed the following: “CO<sub>2</sub> has been removed and water based suppression is being installed on selected units. Water based fire suppression currently being installed on the following Hydro generators Tumut 1 generators (4x 82.4MW), Tumut 2 generators (4x 71.6MW). Planning to install water based fire suppression at Tumut 3 (6x 250MW), Murray 1 (10x 95MW), Murray 2 (4x 138MW) & Guthega (2x 30MW).”

The German User coded EMP048 informed that he uses: “NO<sub>2</sub> gas.”

The Japanese companies rely on dry chemical powder (extinguishers) as the User coded EMP028 commented: “Dry-chemical extinguisher in portable execution for manual application (no fix system installation). We have over 200 hydro generators. Those capacities are about 100kW to 300,000kW.” This is a interesting information because in no other country this method is used for such large units; moreover the use in form of extinguisher is quite peculiar.

**D 1.6.2 -**

1.6.2) If yes, please indicate which are you're the different fire protection systems you have installed:

- CO<sub>2</sub> - how many units?
- Water Spray - how many units?
- Inergen - how many units?
- Other - how many units?

If other please indicate here which:

For this question we had many alternatives with additional information. Not only the type of the system used (CO<sub>2</sub>, Water, Inergen or Other) but also the quantity of protected units. The way to solve the complexity of this question and to show the answer was in form of a composed table as follows:

<b>Company code/country</b>	<b>CO<sub>2</sub></b>	<b>Water Spray</b>	<b>Inergen</b>	<b>Other units number</b>	<b>Others description**</b>
EMP005 - SUI	blank	blank	blank	blank	blank
EMP006 - SUI	15	blank	6	blank	blank
EMP015 - NZL	4	8	blank	blank	blank
EMP019 - SWE	no actual figure available too many	blank	blank	no quantity indication	Relay protection + VESDA
EMP021 - CHN	3	Almost all generator in China applies water spray.	blank	blank	blank
EMP026 - SWE	1	blank	blank	blank	do not match with the question
EMP031 - MEX	6	2	blank	no quantity indication	Foam
EMP032 - CAN	2	78	blank	blank	blank
EMP033 - NZL	32	blank	7	blank	blank
EMP056 - SUI	14	1	38	1	N2
EMP054 - AUT	22	blank	blank	246	4 Dry fire fighting pipe + 242 without GFP
EMP051 - AUT	2	2		no quantity indication	All other units have no GFP
Totals*	101	91	51		

(\*) About the quantity of protected units the numbers indicated on the bottom line of the table above are the sum of the indicated quantities; we call the attention to the fact that the real number is not known because of remarks as “almost all the generator in China apply water spray” and the lack of quantity indication by other involved Users.

We point out the use of Inergen as extinguishing media, an inert gas mixture that imposes no harm to operators and is a GREEN media, leaves no residue, do not require special extraction facilities, and do not impose any harm to the equipment either; all this being a proven extinction system.

(\*\*) we reproduce here some of the complete descriptions given to the question “if other please indicate here which”. The Swedish User coded EMP019 informed that: “On some of our bitumen windings we have CO<sub>2</sub> fire protection. We are trying to take these away and replace them with high quality relay protection sometimes combined with smoke sniffers. No water or Inergen or others if these sniffers don’t count. Our company has 241 HPP so it is difficult to tell the real number of CO<sub>2</sub> systems but they are fewer all the time and there are no CO<sub>2</sub> systems or others when the winding is of epoxy type.” Also referring to the high degree of difficulty to give detailed figures because of the great quantity of units they have we reproduce the comment stated by the Canadian User coded EMP032 as follows: “Please note that we have 78 Hydroelectric and 2 combustion Turbines (CT Units). These two CT units are equipped with CO<sub>2</sub> enforced by the CT supplier”. And there are many units without GFP as the Austrian User coded EMP054 informs: “242 units have no fire protection system.” This procedure was corroborated by another Austrian User coded EMP051 that informed that he has 2 units with CO<sub>2</sub> and 2 with water and complemented: “All other units of our organization are NOT equipped with a fire protection system.”

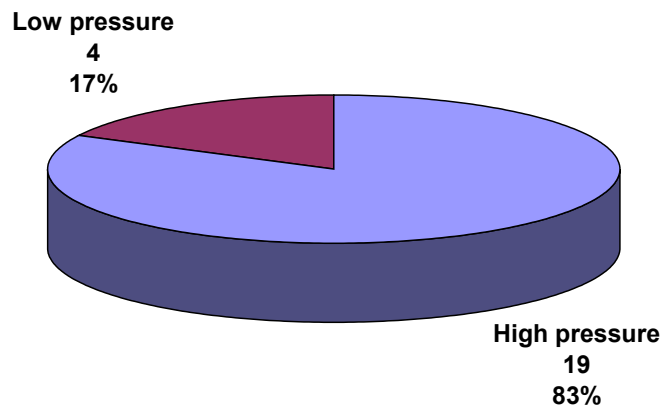
**D 1.6.3 -**

1.6.3) In the case of CO<sub>2</sub> please indicate the pressure system used:  
 - High pressure  
 - Low pressure  
 Any comment on this issue?

This question was somewhat specific because some of the involved Users use only high pressure CO<sub>2</sub> systems and even do not have information about the low pressure system.

The result of this question can be seen below:

**1.6.3) In the case of CO<sub>2</sub> please indicate the pressure system used:**



This survey has 12 Blank answers – not considered in the graph.

Open question analysis results (any comment on this issue):

No categorized survey was applicable in this case. The majority uses high pressure system, as for example the User from New Zealand, coded EMP033, which informed: *“High pressure CO<sub>2</sub> systems comprising CO<sub>2</sub> cylinder banks.”* Some companies use both systems, as informed the Brazilian company coded EMP016 that reported: *“We use both, high and low pressure systems in different power plants.”* Two companies informed that they intend to remove the CO<sub>2</sub> systems, here the statement of a User from New Zealand, coded EMP015: *“Will eventually be remove and replaced with a water fogging system, but not a high priority at this stage. We have removed the CO<sub>2</sub> from the other station because it released more into the lower galleries than into the machine enclosure and posed a signification risk to staff on the station, if working at lower levels when the CO<sub>2</sub> was discharged.”* – Which points out to a probable design error on the CO<sub>2</sub> system project?

**D 1.6.4 -**

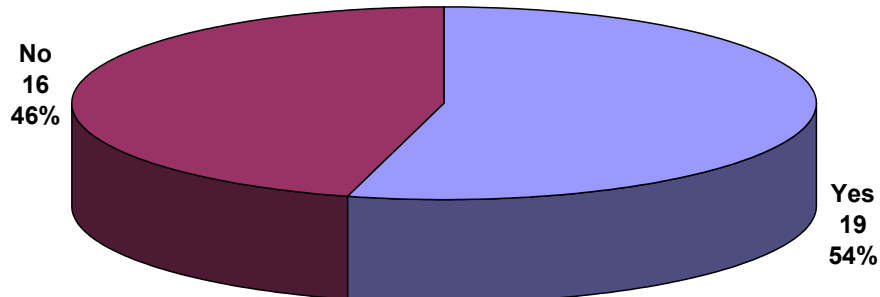
1.6.4) Do you have generators with open circuit ventilation?

- Yes  - No

If yes, which kind of fire protection, if any, do they have?

This question was stated due to the fact that open circuit generators usually need special care in the design and application of GFP. The result of this survey

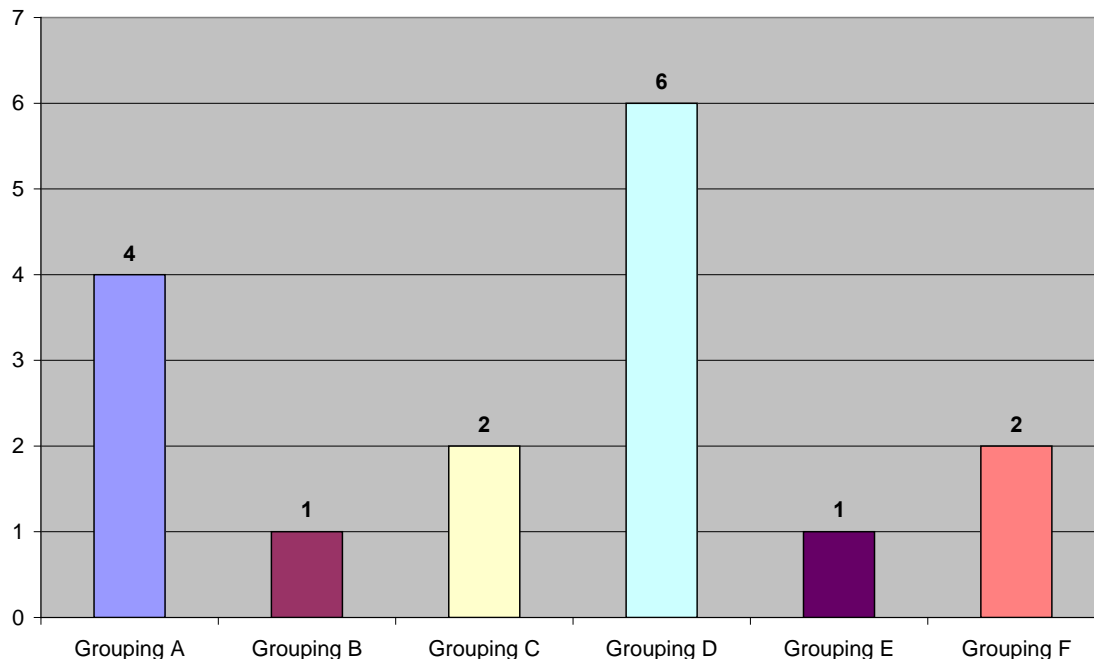
**1.6.4) Do you have generators with open circuit ventilation?**



The quantity of Users that have open circuit ventilation generators amounts to 54% of the involved companies.

Open question analysis results (If yes, which kind of fire protection, if any, do they have?):  
A complement question was made asking if yes, which kind of fire protection, if any, they have. A categorized study revealed the following result:

1.6.4) Do you have generators with open circuit ventilation? If yes, which kind of fire protection, if any, do they have?		
Grouping A	CO2	4
Grouping B	Dry Powder	1
Grouping C	CO2 and other - Foam or Inergen	2
Grouping D	No protection available or none generator with open circuit ventilation	6
Grouping E	NO2	1
Grouping F	Water spay	2
Grouping G	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of answered questions</b>		<b>17</b>



The no protection alternative appears with the greater number of examples (6), CO2 comes next (4), then with 2 Water Spray and the interesting application of Foam in generator fire protection.

The application of CO2 in such type of machines requires additional components as the User from Macedonia, coded EMP027, commented: *“We have two Generators with power 9,5 MVA and they are in operation since 1959. The cooling system of the generator is open circuit ventilation with air. They have installed stationary fire protection with CO<sub>2</sub> under the high pressure. The design for fire protection is to close inlet and outlet gate for cooling air and activate CO2 if fire will be detected in the generator by relay protection.”*

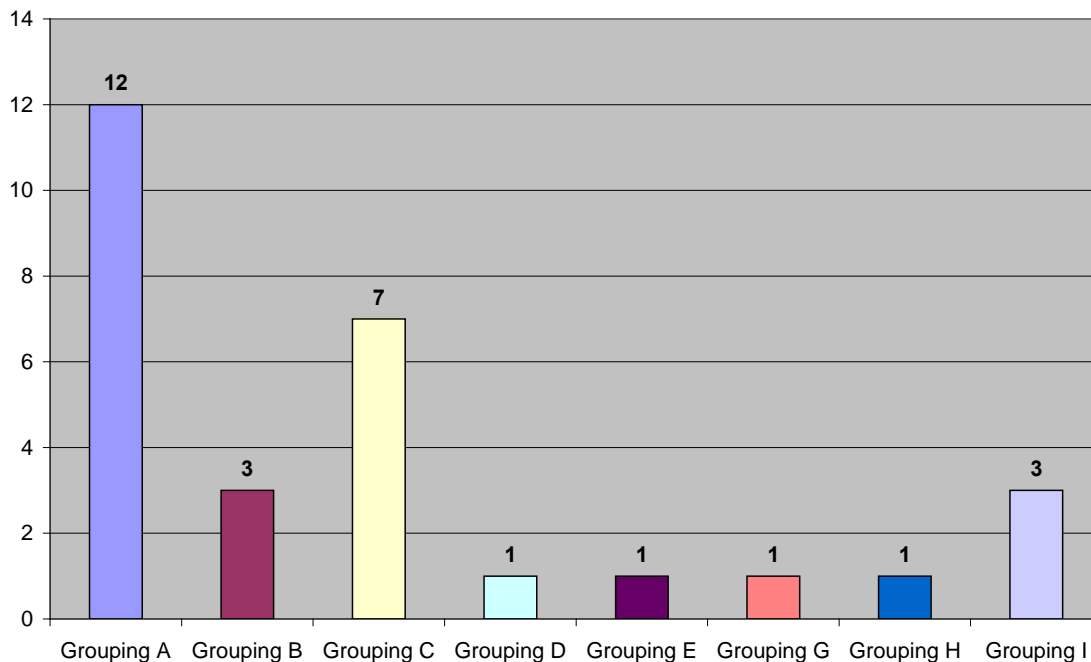
#### D 1.7 -

1.7) In your opinion/experience what is the most efficient fire extinguishing media?

This block, composed by four questions deals with questions directly connected to the extinguishing medias; most efficient, harmful to machines and human health and environmental concerns.

Starting with the question 1.7 that is a pure open question and the quantity of answers allowed the categorized study and resulted in the graphic below:

<b>1.7) In your opinion/experience what is the most efficient fire extinguishing media?</b>		
Grouping A	CO2	12
Grouping B	Inergen (inert gas)	3
Grouping C	Water	7
Grouping D	Avoid fire begin (prevention)	1
Grouping E	Depends on type of application	1
Grouping F	Blank (no answer) - (not considered for the graphic)	6
Grouping G	Fire Extinguisher	1
Grouping H	Foam extinguisher	1
Grouping I	No experience or no opinion	3
<b>Total of answered questions</b>		<b>35</b>



The result confirmed the preference for CO2 considered as most efficient extinguishing media by 12 Users, in second place water was indicated by 7 Users and Inergen got 3 favorable opinions (as a new media for hydro generators this is an interesting result).

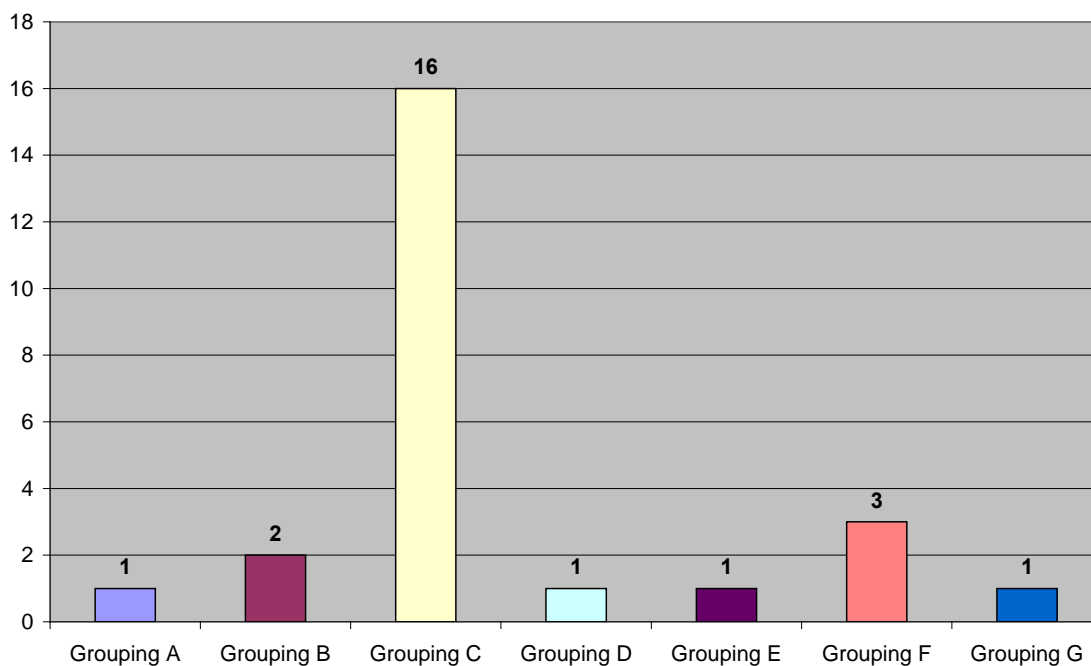
The comments given can be seen on the correspondent annex. This question had 6 blank answers not considered in the graphic above.

#### D 1.7.1 -

1.7.1) Which media is harmful to the machines?

This question was also stated as a pure open question with the following results of the categorized study:

1.7.1) Which media is harmful to the machines?		
Grouping A	CO2	1
Grouping B	Gas or Halon	2
Grouping C	Water	16
Grouping D	Gas - Water	1
Grouping E	Chemical Dust	1
Grouping F	Not defined or None	3
Grouping G	No experience or no opinion	1
Grouping H	Blank (not considered for the graphic)	10
<b>Total of answered questions</b>		<b>35</b>



A significant result shows that 16 Users consider water as being more harmful to the machines. This information is consistent with several reports received from experienced erection and maintenance people that recall problems with the refurbishment of units in which fire were extinguished with water and that show severe oxidation problems even in units allegedly protected by “special” varnish coating.

The answers can be seen in the enclosure.

#### D 1.7.2 -

1.7.2) Which media is harmful to the human health?

This question was also stated as a pure open question. In order to evaluate the different answers given the table below was issued:

1.7.2	Alternatives indicated for this item							
	CO2	Halon	N2	Foam	any gas	C. Powder	Nothing	Blank
EMP013-BRA								1
EMP051-AUT								1
EMP009-CHN								1
EMP026-SWE								1
EMP038-SWE								1
EMP045-BRA	1	1				1		
EMP005-SUI	1							
EMP028-JPN	1							
EMP037-RUS	1							
EMP010-CAN	1							
EMP012-MEX	1							
EMP043-JPN	1							
EMP008-BRA	1							
EMP016-BRA	1							
EMP019-SWE	1							
EMP027-MKD	1							
EMP025-BRA	1							
EMP039-AUS	1							
EMP032-CAN	1							
EMP033-NZL	1							
EMP036-CAN	1							
EMP047-SWE	1							
EMP055-USA	1							
EMP058-BRA	1							
EMP040-NOR	1	1						
EMP056-SUI	1		1					
EMP021-CHN	1							
EMP023-ESP	1							
EMP015-NZL	1				1			
EMP031-MEX	1			1				
EMP054-AUT	1	1						
EMP020-BRA	1	1						
EMP048-GER	1		1					
EMP006-SUI			1					
EMP053-POL							1	
Totals	28	4	3	1	1	1	1	5

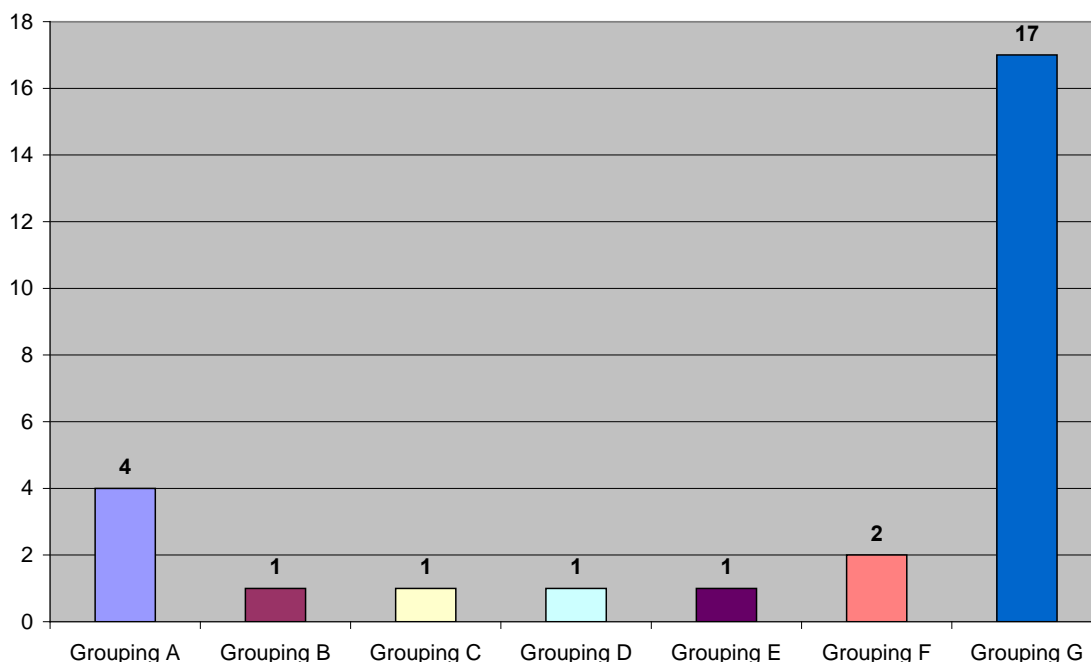
We recall that this question was a pure open question so that the alternatives were indicated by the Users. CO2 was considered the most harmful media for the human health. This is explained by the comment issued by the Spanish User, coded as EMP023-ESP, as follows: “CO2 is harmful to the human health because displacing of air and it is necessary to remove CO2 of stator room before the entry of personnel to the stator area.”

**D 1.7.3 - Is there any environmental concern bound to any media currently in use?**

1.7.3) Is there any environmental concern bound to any media currently in use?

This question was also stated as a pure open question with the following results of the categorized study:

1.7.3) Is there any environmental concern bound to any media currently in use?		
Grouping A	Yes for CO2	4
Grouping B	Yes for CO2 and Halon	1
Grouping C	Yes for FM200	1
Grouping D	Halon	1
Grouping E	Greenhouse gas - but no additional explanation given	1
Grouping F	Yes - but no additional explanation given	2
Grouping G	No concern	17
Grouping H	Blank - no answer (not considered for the graphic)	8
<b>Total of answered questions</b>		<b>35</b>



For 17 Users there is no concern, but some of the given explanations did show a probable lack of information about CO<sub>2</sub> used as extinguishing media, as for instance the answer given by the American company coded as EMP055-USA, that wrote: “CO<sub>2</sub> may have harmful effect to worldwide greenhouse warming.” In fact the CO<sub>2</sub> used in fire protection is usually obtained from usual industrial processes, as for instance beer breweries, that generate CO<sub>2</sub> in the context of their usual industrial process. Part of this CO<sub>2</sub> is trapped and compressed in cylinders for use as extinguishing media. Being so this CO<sub>2</sub> is only liberated to the air in case of a fire accident. This fact redeemed the CO<sub>2</sub> used for fire combat from being considered as harmful to the environment – fact that is confirmed by many environmental institutes.

Other environmental aspect that was not raised here is the given contributions were the requirements concerning the waist water resulting from fire extinction. This water is highly contaminated and in many countries there are specific rules that require that a special piping and collect tank for this waist water is installed and that the waist water is treated before it is returned to the river.

**D 1.8 -**

1.8) Do you specify measures to prevent accidents to personnel?

- Yes  - No

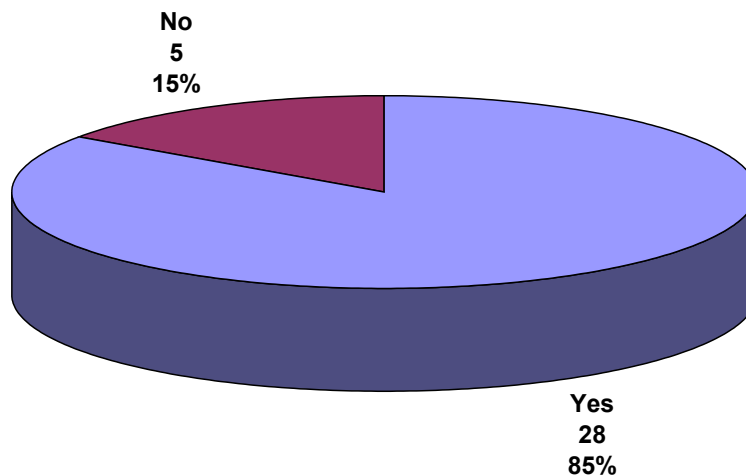
If yes, please specify:

This block deals with the prevention of accidents with personnel and prevention of machine damages and comprises the questions 1.8 and 1.8.1.

This item 1.8 has a check-box question and an open question to get more experience data.

Starting with the check-box question:

**1.8) Do you specify measures to prevent accidents to personnel?**



This survey has 2 Blank answers – not considered in the graph.

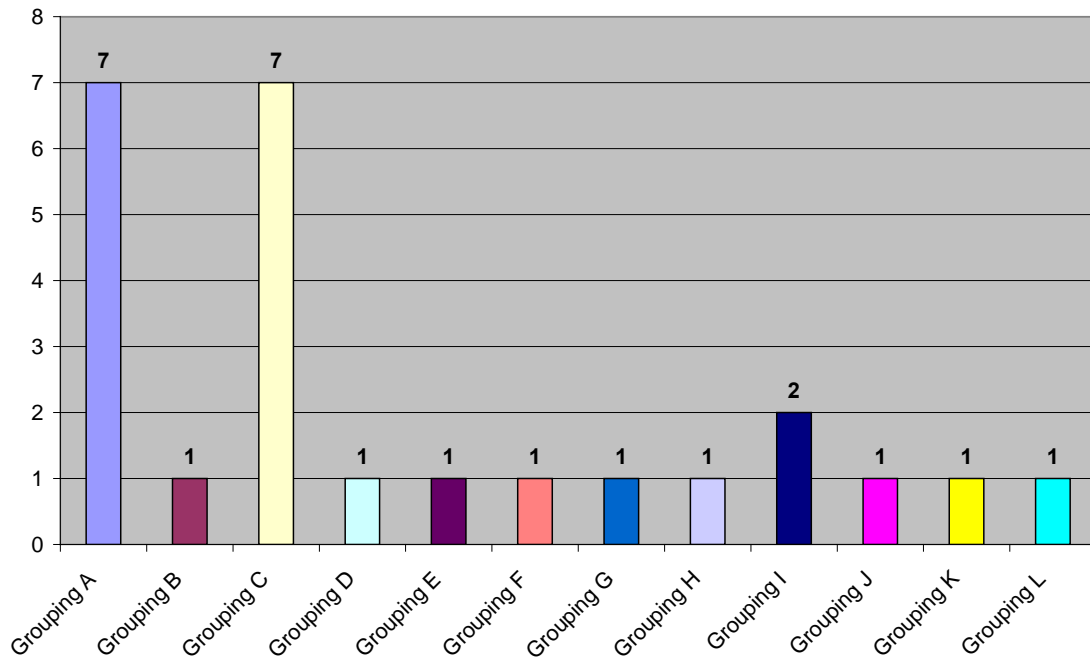
The majority of Users, 80%, indicated that they are concerned with accident to personnel and that specific measures are undertaken to prevent accidents.

Open question analysis results (If yes, please specify):

The open questions asking Users to specify which measures are undertaken was analyzed by a categorized study that showed the following result:

<b>1.8) Do you specify measures to prevent accidents to personnel? If yes, please specify:</b>		
Grouping A	People trained according to regulations, accident prevention policy	7
Grouping B	Audible warning for evacuation of the area	1
Grouping C	Automatic and manual (CO2) interlocking, disconnect system before going in to room - for inspection or maintenance	7
Grouping D	CO2 systems are not acceptable	1
Grouping E	Forbid to enter housing after CO2 discharge	1
Grouping F	Fire alarm and emergency exit lightning	1
Grouping G	Fire Door	1

Grouping H	Isolation requirements and choice of media	1
Grouping I	Forbid access to CO2 protected areas when system is activated	2
Grouping J	Eliminate CO2 systems when relay system is sufficient	1
Grouping K	Implementation of fire compartments on power plants	1
Grouping L	Planning to remove CO2	1
Grouping M	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of additional information given</b>		<b>26</b>



The indications of application of personnel training according to accident prevention policies is a very positive result; as commented by the Chinese User, coded EMP021-CHN: *“All the staff working inside the plant have more knowledge which is clearly indicate in the notice and regulation. They know how to protect themselves and move in correct direction and use of the hydrant. They have well.”*

Other aspect that was pointed out is the precaution for units protected by CO<sub>2</sub> that appears on several of the groupings above. As an example we reproduce the comment issued by the Brazilian User coded EMP045: *“It is not allowed to get inside the housing when the fire protection system is activated; specific training programs for the Fire Brigade; creation of appropriate routes for fire escape.”* Another critical moment is when the unit is undergoing maintenance works and the Polish User coded EMP053 commented the following: *“During generator overhaul mechanical stoppers are installed on CO2 valves to prevent CO2 injection into generator interior when people is working.”*

The remaining comments can be seen on the corresponding annexes.

#### D 1.8.1 -

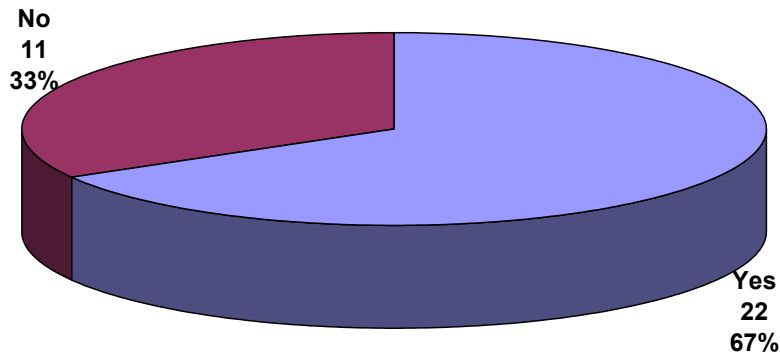
1.8.1) Do you specify measures to prevent damage to machine?

- Yes  - No

If yes, please specify:

This item has a check-box question and an open question to get more experience data. Starting with the check-box question:

**1.8.1 - Do you specify measures to prevent damage to machine?**



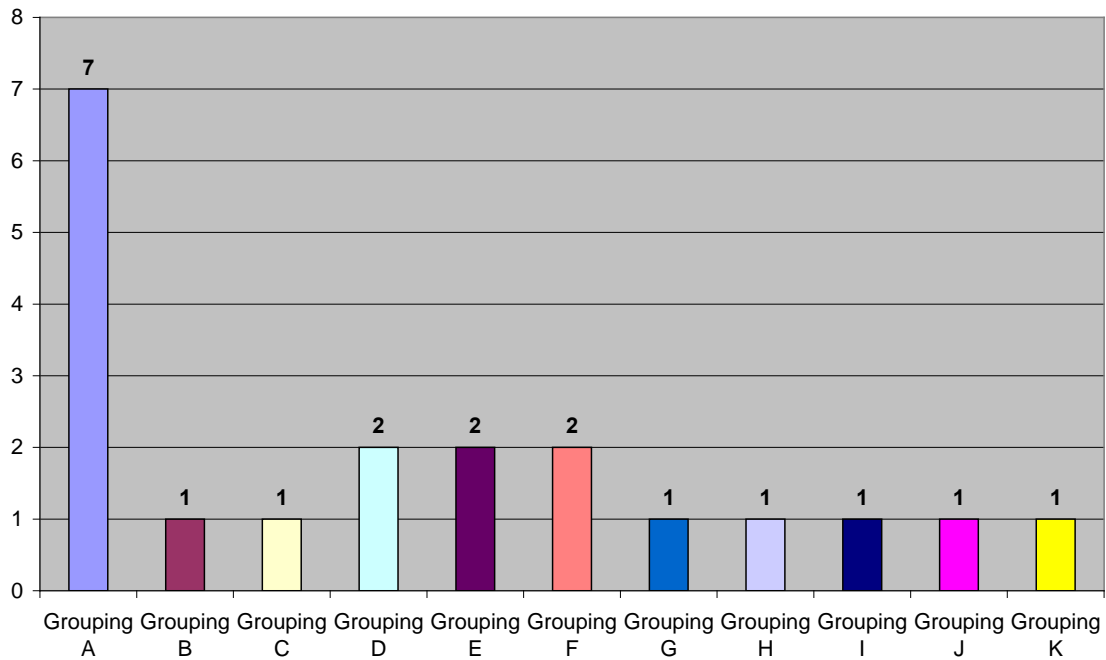
This survey has 2 Blank answers – not considered in the graph.

The result shows that the Users are also concerned about their machines situation.

Open question analysis results (If yes, please specify):

The open questions asking Users to specify which measures are undertaken was analyzed by a categorized study that showed the following result:

<b>1.8.1) Do you specify measures to prevent damage to machine? If yes, please specify:</b>		
Grouping A	Automatic protection, relays, release start interlocks	7
Grouping B	Fire door	1
Grouping C	Use of special detection (VESDA)	1
Grouping D	Keep CO2 sprays distant from machine components	2
Grouping E	Monitoring of machine values, temperatures, ozone levels, etc.	2
Grouping F	Following manuals	2
Grouping G	Safety prevention during maintenance	1
Grouping H	Access restriction	1
Grouping I	Inspection by external authorities	1
Grouping J	Use of non flammable material	1
Grouping K	Water extinction is not acceptable	1
Grouping L	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of additional information given</b>		<b>22</b>



The total of seven answers could be categorized as “Automatic protection, relays, release start interlocks” indicating way this Users keep their units. The Brazilian User coded as EMP058 informed the following: *“All protection is done by automatic protection system independent of personnel action. Manual protection is used when the operator is sure of fire existence and system had a failure.”*

One of the given additional information recalled the use of modern aspiration type smoke detectors in hydro generators fire protection, this was the contribution of a User from New Zealand, coded EMP015, that said that they protect their units by: *“Installing VESDA detection systems and require both a VESDA level 4 activation plus a differential protection relay operation before water is actually discharged into the generator. There is a manual discharge capability, but it still requires the VESDA level four activation.”*

For the other comments please refer to the specific annex.

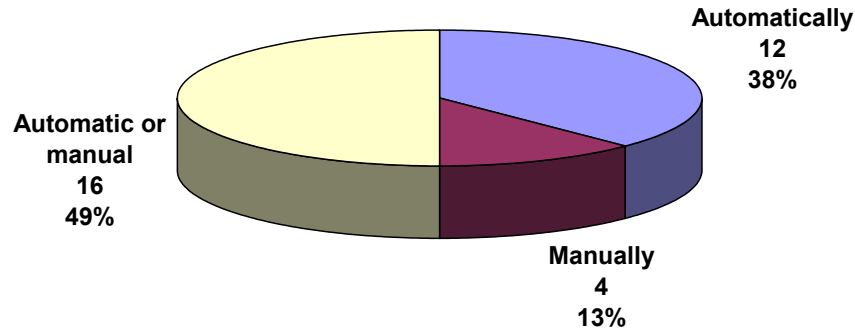
#### D 1.9 -

1.9) By what means is the existing generator fire extinguishing system is designed to release?  Automatically  
 Manually or  
 Either automatic or manual.  
If you have different fire protection systems please repeat the answer to each different fire protection system.

This block, composed by the questions 1.9 and 1.9.1, deals with the GFP release schemes; the installed and the preferred ones.

Starting with the pure check-box question 1.9, which gave the choice between automatic release, manual or selectable both, either or, we came to the result:

**1.9) By what means is the existing generator fire extinguishing system is designed to release?**



This survey has 3 Blank answers – not considered in the graph.

The flexible alternative either automatic or manual got 46% of the votes. As to be expected the pure manual alternative got only 4%.

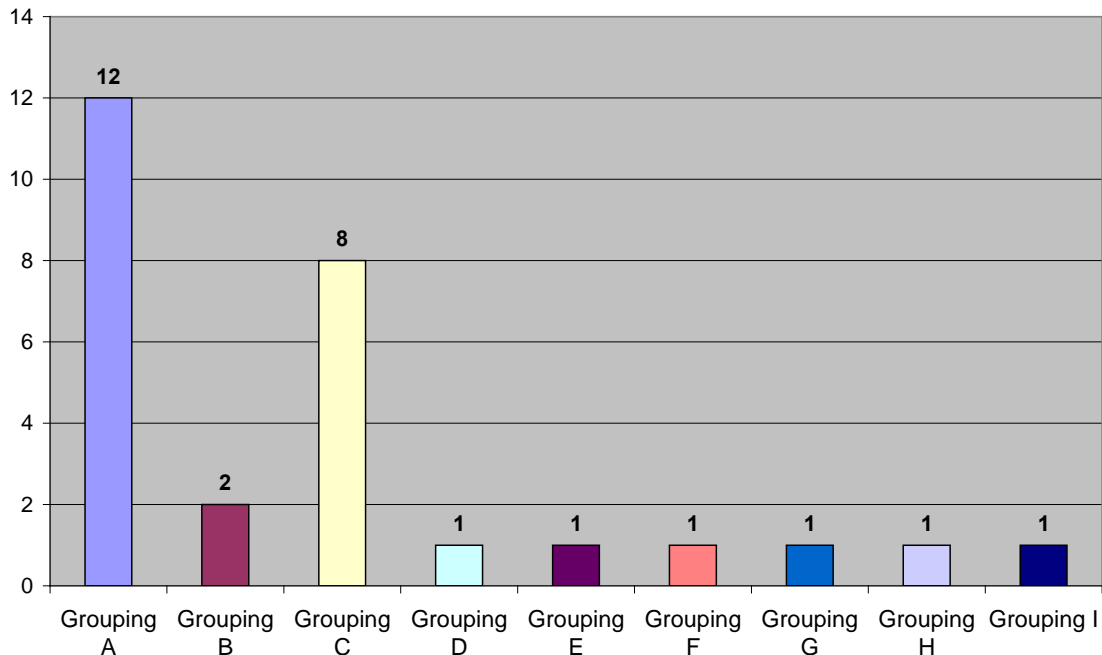
NOTE: this question was also included in the “form for multiple machines” and from the few answers received only one brought one answer with coherent values that did not interfere in the overall statistics tendency.

**D 1.9.1 - What is your opinion or preferred method, as to how the generator fire extinguishing system should be released?**

1.9.1) What is your opinion or preferred method, as to how the generator fire extinguishing system should be released?

This is a pure open question that resulted in the following categorized analysis:

<b>1.9.1) What is your opinion or preferred method, as to how the generator fire extinguishing system should be released?</b>		
Grouping A	Automatic	12
Grouping B	Manual	2
Grouping C	Automatic or manual (some with semi-automatic alternative)	8
Grouping D	If any: Automatic, provided with GFP than automatic provided that is will be de-energized when personnel in in the power station	1
Grouping E	Automatic or manual but with VESDA (smoke detector) level 4 activation	1
Grouping F	Automatic or manual but with thermal sensors interlock	1
Grouping G	Must have activated detectors and split phase operation	1
Grouping H	Temperature and generator relay interlock for actuation	1
Grouping I	Too little experience	1
Grouping J	Answer does not match the subject asked (not considered for the graphic)	7



For this question we received many answers and the compilation of them by means of a categorized study forming categories to enable the issue of a graphic to extract a tendency among the Users was not a simple task due to the diversity of the answers. But in general it is possible to say that the variations involving automatic in conjunction with a manual alternative, or at least manual trip possibility, were the most often indicated answers. And particular situation also were mentioned as “*automatic as station are not manned*” – here it is to mention that we saw Users the have unmanned plants and leave the GFP equipment on manual resulting in a big risk for the plant.

Her we have a typical “philosophy” question, each company developed their own GFP triggering strategy. Some Users do prefer a wide flexibility, as the Chinese User, coded EMP022: “*We prefer to operate the system with fully automatic, semi-automatic and in combination with manual method.*”

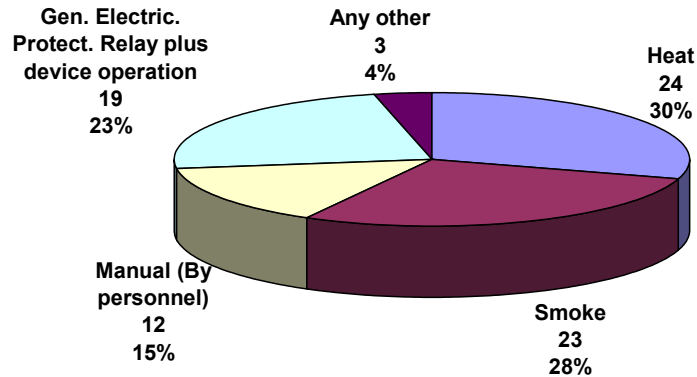
#### D 1.10 -

1.10) How is the fire detected in your generators? Please tick the box.

- Heat
- Smoke
- Manual (By personnel)
- Generator Electrical Protection relay operation plus one of above device operation
- Any other; please specify:

This is a check box question with one alternative that calls for additional information (any other; please specify). The graphic below shows this question’s results:

**1.10 - How is the fire detected in your generators?**



This survey has 1 Blank answer – not considered in the graph.

The usual detection systems, heat and smoke and the combination of them are more common. Although it is quite interesting to observe that 15% of the answers recalled for manual operation made by the operators.

Open question analysis results (any other; please specify):

The three additional explanations received can be seen on the annex. As an example we reproduce the comment sent by the German User coded: “*Smoke (detectors) not by all-there are some generators that do not have smoke detectors due to the room temperature that is too high for these sensors.*”

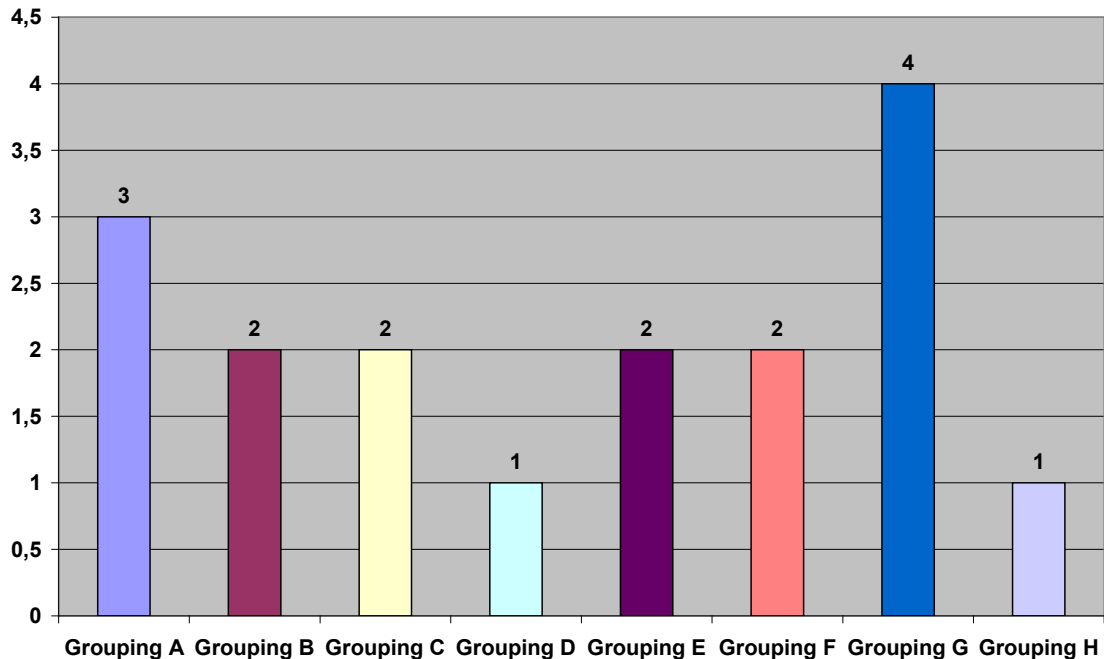
**D 1.10.1 -**

1.10.1) Do you have any comment about the efficiency of these detectors (heat and/or smoke)?

This is a pure open question open to all 35 Users’ comments, 25 contributions were given (10 Users did not comment – 10 blanks); this allowed a categorized study of them and the results can be seen below:

<b>1.10.1) Do you have any comment about the efficiency of these detectors (heat and/or smoke)?</b>		
Grouping A	Standard Smoke detectors are reliable	3
Grouping B	Standard Smoke detectors are NOT reliable	2
Grouping C	Smoke detectors by aspiration (VESDA) are more reliable	2
Grouping D	Both smoke and thermal are reliable	1
Grouping E	Both smoke and thermal are NOT reliable	2
Grouping F	No comparison available	2

Grouping G	No comment	4
Grouping H	Smoke with radioactive elements require special handling care	1
Grouping I	Answer does not match the subject asked (not considered for the graphic)	8
Grouping J	Blank (not considered for the graphic)	10
<b>Total of answered questions</b>		<b>35</b>



This question showed that the opinions are splitted concerning the detectors type thus there is no clear tendency, but again the smoke detectors by aspiration (VESDA) were mentioned showing the advance of the use of this type of detectors in hydro generation. In this respect we got an interesting contribution from a User from New Zealand, coded EMP033 that reports the company philosophy in respect to detection: *“Smoke detection is seen as the most efficient as very small levels of smoke particles indicating the very early stages of a fire can be sensed by an aspirating smoke sensing system. For thermal detection to operate the temperature within the generator enclosure or windings themselves needs to reach much higher elevated levels before activating the generator fire protection system. This takes a considerable longer time compared to the activation time provided by smoke detection which may result in considerable more fire damage to the generator. ‘Our company’ employs an efficient automatic detection system using a voting system whereby any two of heat, smoke or generator electrical protection systems needs to be true to initiate an activation of the fire protection system. This also reduces the amount of accidental activations of the generator fire protection system.”*

We also got some answers that, although expressing valid concerns, did not match the subject asked. Here two examples for the records. The Chinese User coded EMP021 stated: *“How to prevent influence from vibration or electromagnetic field to the precise measurement of these detectors is our problem.”* The Canadian User coded EMP032 expressed the following: *“Install two system: Incipient or early warning to alert the operator without deluge operation and smoke detection interlocked with ‘86 lock-out’ electrical protection”* which is an interesting proposition for the GFP operational philosophy but does not comment about the detectors’ efficiency.

The whole set of contributions can be seen on the corresponding annex.

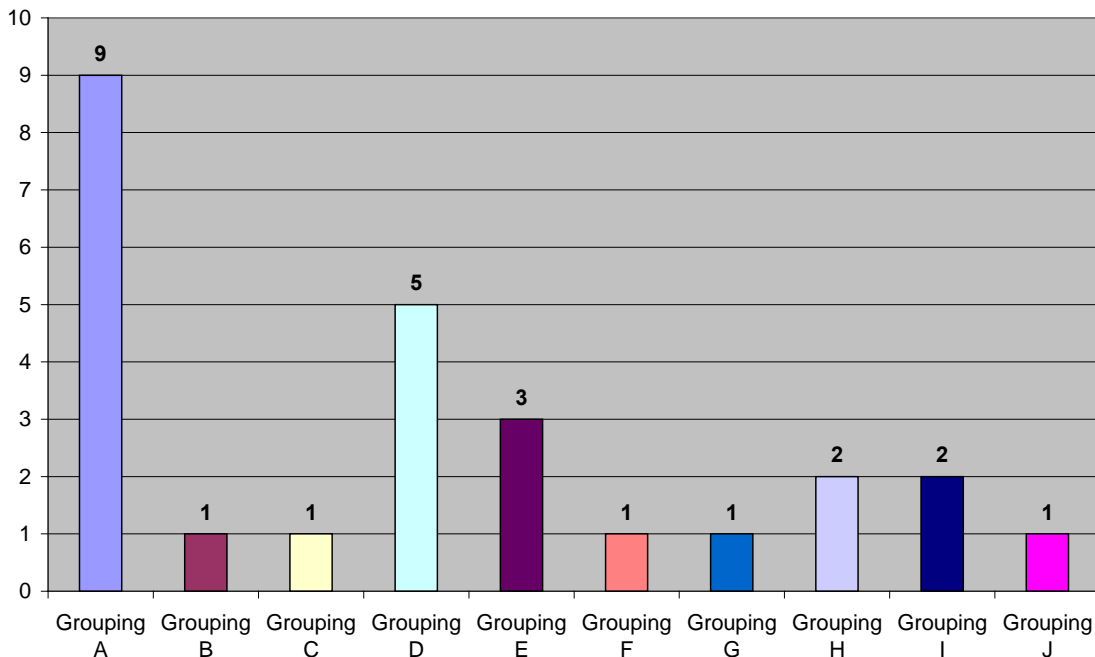
**D 1.11 -**

1.11) How do you prevent unwanted (unnecessary-accidental) release of generator fire extinguishing system? (Eg- dual detection method)

Please specify here:

For the sake of completion we recall the categorized study already presented in the first part of this work.

Grouping	Legend	Quantity
Grouping A	Dual protection	9
Grouping B	No protection for unwanted trip	1
Grouping C	VESDA detection system	1
Grouping D	Include generator electrical protection (eg. Differential Relay)	5
Grouping E	Block CO2 at inspection works	3
Grouping F	Mechanical stoppers	1
Grouping G	Manual activation	1
Grouping H	Voting system involving two out of smoke or heat detectors, or electrical protection	2
Grouping I	Check fire alarms in intervals	2
Grouping J	Trip occurs if any of the available detectors (heat or smoke) or electrical protection actuates	1
Grouping K	Did not answer (not considered for the graphic)	9



The received answers show that the use of dual protection, including the generator's electrical protection and blocking of CO<sub>2</sub> during maintenance show up as most commonly used methods to prevent unwanted GFP release. As an example of the comments given in favor of the dual protection (Grouping A) we reproduce what an Austrian User coded EMP054 reported: "We have 3 circuits of heat and smoke detector in the generator ring area (inside the generator housing). If 2 circuits are activated the extinguishing system

starts. If the door of the generator ring (housing) area is open the CO<sub>2</sub> extinguishing system is blocked.” The inclusion of the generator electrical protection (Grouping D) was commented by the Brazilian User coded EMP045 in the following way: “We try to prevent unwanted release of the system using the information of the sensors integrated with the electric protection of the generator.”

About the blocking of CO<sub>2</sub> during maintenance (Grouping E) the Swedish company coded EMP019 sent the following comment: “The CO<sub>2</sub> system is blocked when there is work going on inside the generator i.e. inspection.”

For all the given comments pleas relay to the corresponding annex.

#### D 1.11.1 -

1.11.1) At your present installation did you have unwanted (unnecessary-accidental) release of generator fire extinguishing system with consequent release of extinguishing media?

- Yes  - No

If yes, please specify:

Number of unwanted (unnecessary-accidental) releases of fire protection per unit per year:

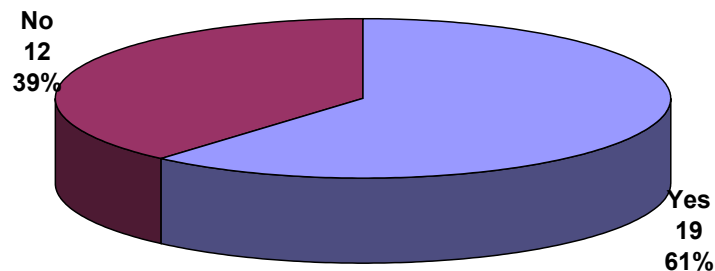
Outage duration that resulted due to clean up:

If you know the reason of these incidents, please specify?

This question had a complex structure that started with a check-box question that was complemented with 3 open questions calling for specific additional information.

Starting with the result of the check-box question:

**1.11.1 - At your present installation did you have unwanted (unnecessary-accidental) release of generator fire extinguishing system with consequent release of extinguishing media?**



This survey has 4 Blank answers – not considered in the graph.

Open question analysis results this question was complemented by three additional exploratory questions that are shown in the table below with the corresponding answers. Due to the diversity of answers the best way to present the contributions is in form of a table.

Users	Number of unwanted (unnecessary-accidental) releases of fire protection per unit per year:	Outage duration that resulted due to clean up:	If you know the reason of these incidents, please specify?
EMP005-SUI	blank	blank	blank
EMP013-BRA	blank	blank	blank
EMP051-AUT	blank	blank	blank
EMP009-JPN	blank	blank	blank
EMP028-JPN	blank	blank	blank
EMP037-RUS	blank	blank	blank
EMP010-CAN	blank	blank	blank
EMP012-MEX	blank	blank	blank
EMP016-BRA	blank	blank	blank
EMP019-SWE	blank	blank	blank
EMP020-BRA	blank	8 hours	blank
EMP021-CHN	blank	blank	blank
EMP027-MKD	blank	6 hours	electrical damage outside the generator
EMP026-SWE	blank	blank	blank
EMP053-POL	blank	blank	blank
EMP038-SWE	blank	blank	blank
EMP040-NOR	blank	blank	blank
EMP031-MEX	blank	blank	blank
EMP023-ESP	0,004	blank	Un-adverted tripping of master relays during protection relays testing.
EMP025-BRA	0,004 (2 releases in 20 units in 24 years)	2h 04min	The first unwanted release occurred due to a short-circuit in the GFP board. In the second case, an improper discharge of CO2 and trip occurred due to the incorrect operation of thermal and smoke detectors.
EMP045-BRA	0,03 releases / year for each generator	4 hours	They are: sensor defect, human accidental operation, problems with de CO2 system components.
EMP054-AUT	0,05	0,5 days	faulty activation of protection system
EMP008-BRA	1	blank	accidental
EMP049-SWE	1 release in 20 years	1 day	testing of relay protection, fault in CO2 relay system or detection system
EMP056-SUI	2 in 20 year	0,5 days	faulty manual operation
EMP036-CAN	5 in the last 20 years	7 days or more	blank
EMP032-CAN	>6	7 to 90 days	Welder working in the vicinity of a unit (created smoke) and generator happened to trip on electrical fault, thus triggering the water deluge
EMP006-SUI	approx. 15 since 1981	6 hours	blank
EMP039-AUS	In the past we had one per year CO2 releases- particularly where smoke was one of the inputs and release is managed by a central fire board. We have removed all CO2 installations and now in the process of installing water based protection on selected unit	4 hours	oil casing smoke
EMP048-GER	Multiple releases because of unwanted activation of electrical	blank	blank

	protection.		
EMP043-JPN	One or less	blank	blank
EMP015-NZL	The CO2 system was prone to accidental releases, usually human error, made worse by the fact that it was not a dual activation system.	1 hour	human error
EMP058-BRA	The number per year of unwanted releases of fire protection is about 0.5/year.	3 days	Personal failure operation and same occurrence of false protection operation during commissioning
EMP033-NZL	Typically, one accidental release every 7 years across 39 generator units = 0.004 accidental release per unit per year.	10 hours	Varies, typically false activation of smoke and/or thermal detection system.
EMP055-USA	Unknown	1 to 3 days	false signal

One unwanted outage reason that often occurs is human error and this factor is present in the table above; as it is the case of the User from New Zealand, coded EMP015-NZL, that reported (we repeat): *“The CO2 system was prone to accidental releases, usually human error, made worse by the fact that it was not a dual activation system.”*

There are being made removal of CO<sub>2</sub> systems and substitution by water as it is the case reported by the Australian User, coded EMP039-AUS, (we repeat): *“In the past we had one per year CO<sub>2</sub> releases- particularly where smoke was one of the inputs and release is managed by a central fire board. We have removed all CO<sub>2</sub> installations and now in the process of installing water based protection on selected unit.”* Here we recall the increasing environmental concerns in many countries regarding contaminated water after a fire combat. In one power plant not originally planned for the use of water as extinguishing media the required environmental safe exhaust of water may be either impossible or represent large adaptation works. As the other tendency shows the substitution of CO<sub>2</sub> by inert gas (Inergen for instance) brings a clean and safe solution. Little overhaul works and an residue (or moisture) free extinguishing.

As a matter of fact the good engineering practice tells that the fire extinguishing system is not a matter of a choice and installation after the plant is ready. Nowadays the basic concept of a hydraulic power plant has to consider the particular extinguishing media already at the basic design stage; due to the involved structural provisions that the chosen GFP system may require.

#### D 1.12 -

1.12) In an event of fire is detected by the devices installed (eg. Smoke, heat etc), will extinguishing media release immediately without any delay or any manual interference?

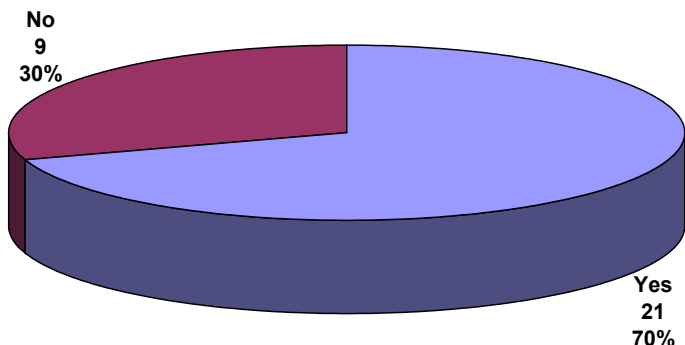
- Yes  - No

If No, please inform the steps of releasing the extinguishing media:

This check-box question is a control question considering former questions. The negative question is explored by an open question.

The check-box question shows the following results:

**1.12 - In an event of fire is detected by the devices installed (eg. Smoke, heat etc), will extinguishing media release immediately without any delay or any manual interference?**



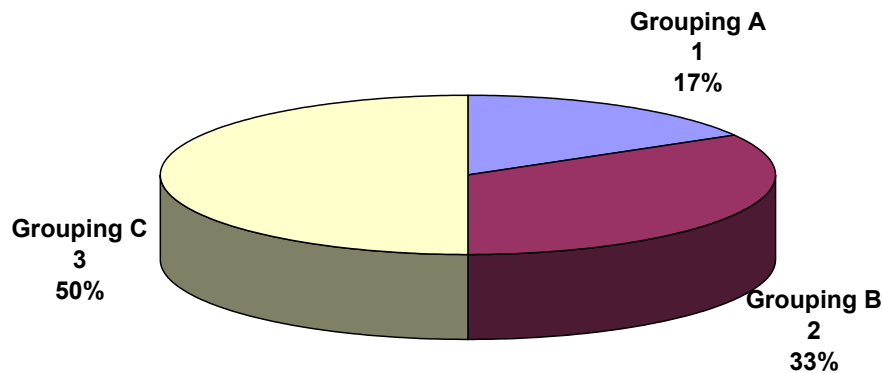
This survey has 5 Blank answers – not considered in the graph.

In this case the 60% (21 Users) of the participant Users do not consider the necessity of having a delay between the detection and the release of the extinguishing media; and those 26% (9 Users) that answered no had the following to say:

Open question analysis results (if No, please inform the steps of releasing the extinguishing media):

<b>1.12) In an event of fire is detected by the devices installed (eg. Smoke, heat etc), will extinguishing media release immediately without any delay or any manual interference?</b>		
<b>If No, please inform the steps of releasing the extinguishing media:</b>		
Grouping A	Alarm (acoustic and optical) comes prior to release	1
Grouping B	Manual release	2
Grouping C	Time delay for release	3
Grouping D	Answer does not match the subject asked (not considered for the graphic)	3
<b>Total of answered questions</b>		<b>9</b>

**1.12) In an event of fire is detected by the devices installed (eg. Smoke, heat etc), will extinguishing media release immediately without any delay or any manual interference?**



The result of the categorized study of the additional explanations given in the case of a delayed release of the extinguishing media shows that in most cases either the delay is caused by a pre-selected times, as for instance the User from New Zealand coded EMP033 reported: *“wait 30 seconds before discharging extinguishing media”*; or by means of manual trip, that inputs an arbitrary delay to the action of releasing the GFP, as informed by the Macedonian User, coded EMP027: *“operator will activated the fire protection.”*

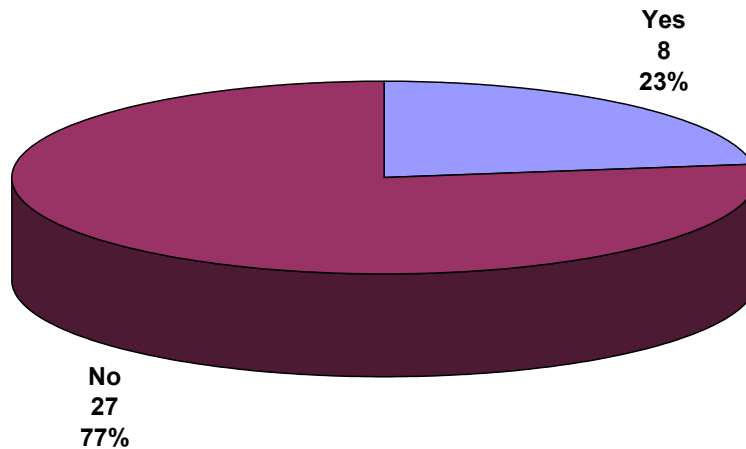
**D 1.13 - Do you consider bearings as a potential fire hazard for generators?**

1.13) Do you consider bearings as a potential fire hazard for generators?  
 - Yes  - No

The questions 1.13 and 1.13.1 deal with a controversial question regarding the bearings as being a fire hazard to be considered in the design and execution of GFP systems. Both items were stated as check-box questions.

The present pure open question 1.13 gave the following result:

**1.13) Do you consider bearings as a potential fire hazard for generators?**



The “tradition” was confirmed herewith with the NO having received 77% (27 Users) votes. On the other hand it is not to neglect the possibility of oil vapour get in to the machine in some constructive types. Although nowadays the initial oil charge uses to be of a special flame retardant oil type it happens sometimes that when the oil is replaced standard type of oil is used increasing the risk to the unit. The occurrence of oil vapour leakage is a kind of “*Achilles’ heel*” for many generator constructors... All this aspects shall be taken in to consideration when a risk assessment study for a particular power plant is made; and it is not to forget that not only the pristine conditions of new generators shall be considered but the real situation after some years of use should not be forgotten.

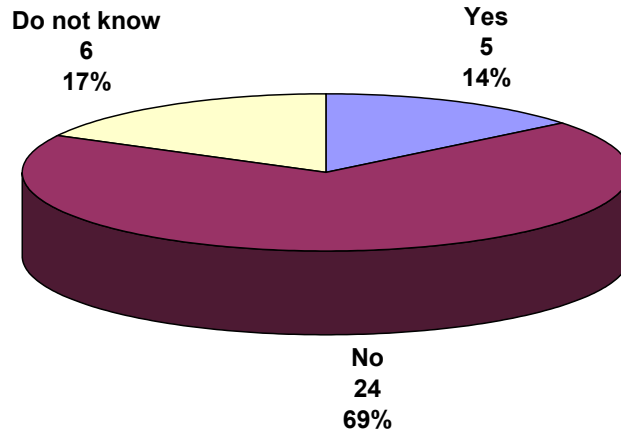
**D 1.13.1 -**

1.13.1) Are your generator fire protection systems designed to fight bearing fires?

- Yes    - No    - Do not know

This is a control question that intends to survey the real bearings protection scheme installed.

**1.13.1 - Are your generator fire protection systems designed to fight bearing fires?**



This is an important result that shows that there are units with fire protection also for their bearings, although it is a quite rare; in this case we had a positive confirmation of at least 14% (5 Users) of the participating companies of a total of 35.

**D 1.14 -**

1.14) Do you specify provisions to remove fire extinguishing media?

- Yes  - No

If yes, for water –spray: does it include provisions for decontamination in case of water used for extinguishing a fire?

Please specify here:

If yes, for CO<sub>2</sub>: do you have an exhaust system that removes the media out of the room?

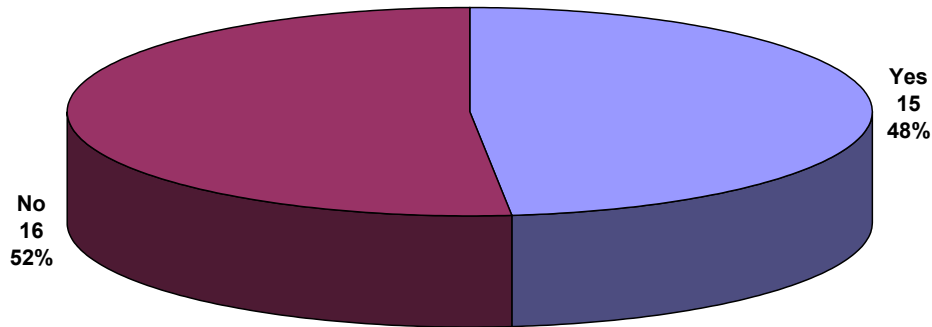
Please specify here:

This question aims to verify the actual quality of the installed GFP design considering its integration in the power plant's design. Normally the provisions for the proper installation, considering the storage (and or supply) of the extinguishing media, the required piping outside the generator pit, as well as the normally required provisions for the removal of the extinguishing media shall be part of the plant's basic design, it means from the very begin of the project. The point addressed by this question is the provisions to remove the fire extinguishing media. Which is quite important moreover if the media used is CO<sub>2</sub>.due to the fact that CO<sub>2</sub>, that is transparent and normally has no smell (in many cases a fragrance is added to make it possible to smell leakages), has a density greater than air and may accumulate in low levels thus causing hazard to staff personnel passing nearby the accident area. If the media used is water there are environmental concerns with the required segregation and treatment of the extinction waste water, as already commented before.

The question was divided in three parts, one check-box question and two exploratory questions dedicated to CO<sub>2</sub> and to water respectively.

The check box result is the following:

**1.14) Do you specify provisions to remove fire extinguishing media?**



This survey has 4 Blank answers – not considered in the graph.

Here we can see that almost the half of the participant Users do not have provisions to exhaust the used fire fighting media. But in order to go a step deeper in this survey let's see the answers for the following open questions:

Open question (1) analysis results (if yes, for water spray: does it include provisions for decontamination in case of water used for extinguishing a fire?):

The 6 received answers were categorized with the result below:

<b>Do you specify provisions to remove fire extinguishing media? If yes, for water-spray: does it include provisions for decontamination in case of water used for extinguishing a fire? Please specify here:</b>		
Grouping A	Drainage of water to decontamination - oil water separator	2
Grouping B	No decontamination foreseen	4
<b>Total of answered questions</b>		<b>6</b>

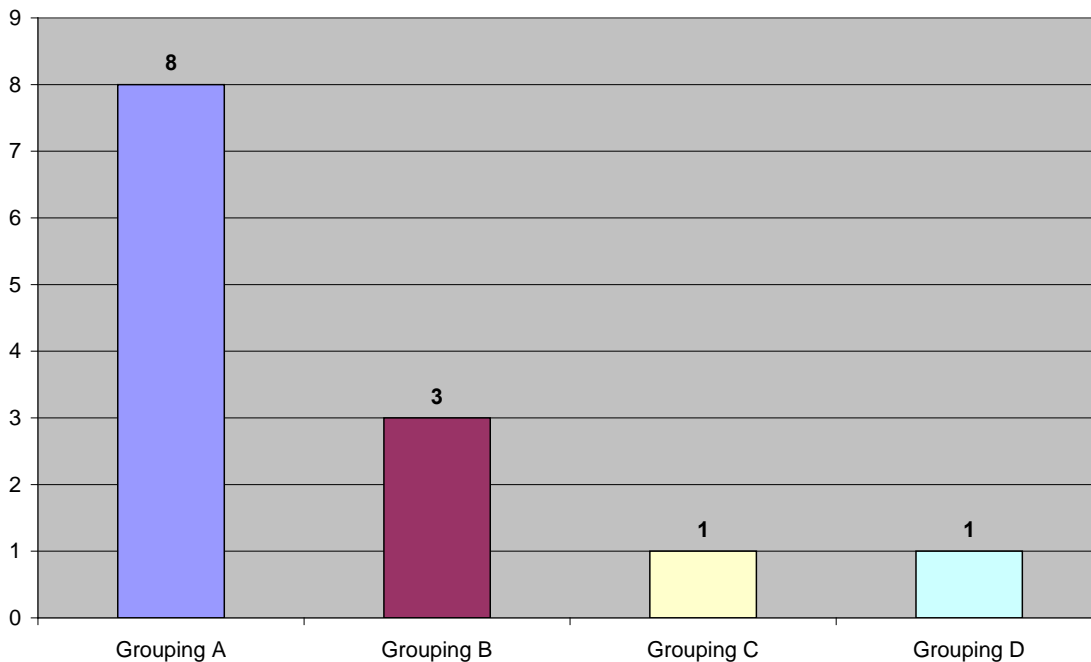
As it can be seen from the table above two companies indicated to have provisions to remove and decontaminate the waist water, this is a quite low figure. This is reported in this way by the Canadian User coded as EMP010: *“The water spray drains into a drainage sump and is filtered through an oil-water separator. Then only the water is pumped out into the surge chamber which runs out into the tailrace tunnel.”*

It is to expect that the next environmental project permissions will call for this type of precaution as a must to be installed.

Open question (2) analysis results (If yes, for CO2: do you have an exhaust system that removes the media out of the room?):

Here the table of the categorized answers shows the following result:

Do you specify provisions to remove fire extinguishing media? If yes, for CO <sub>2</sub> : do you have an exhaust system that removes the media out of the room? Please specify here:		
Grouping A	Fix exhaust system	8
Grouping B	Portable exhaust system	3
Grouping C	Separate exhaust channels	1
Grouping D	No separate exhaust system available	1
<b>Total of answered questions</b>		<b>13</b>



As expected, considering the security of personnel the extraction of CO<sub>2</sub> receives more attention from the Users involved. The most installed alternative is the fix exhaust system. The User from Brazil, coded EMP016, explains the measures that are being implemented concerning this safety issue: *“The CO<sub>2</sub> exhaustion systems that we have are composed by exhausters and pipes that lead the internal generator air to the outside of the power house. The system is operated manually when a CO<sub>2</sub> discharge occurs, to allow the removal of the same from the interior of the generator housing.”*

Next we have the use of portable exhaust systems as the American User, coded EMP055, explains: *“(we) do not have a dedicated system, but use a portable venting system”* by this means the removal of the remaining CO<sub>2</sub> is possible.

#### D 1.15 -

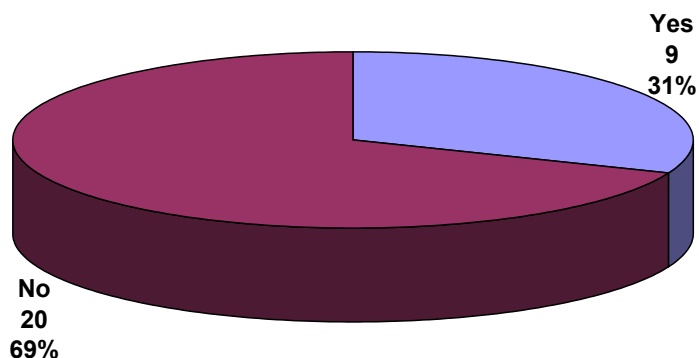
1.15) Do you specify automatic open/close relief vents on the generator housing to relieve excessive inrush extinguishing media pressure while maintaining extinguishing media concentration within the generator housing for the specified extinguishing time?

- Yes    - No

The proper design of a GFP has to take in to consideration the action of the extinguishing media and has to provide conditions for this action to occur properly. In the case of CO<sub>2</sub>, for instance, a certain concentration of CO<sub>2</sub> in the generator has to be kept during a time specified by the corresponding Standards (NFPA for instance). The normal practice is to

have two CO<sub>2</sub> release circuits in the case of total flooding, one for inrush with high pressure, for the first combat; and a second for long time application to keep the required concentration. In this case the generator housing has to keep tight also during the inrush of the first application and no door or other housing closing ought to be destroyed by the inrush overpressure, because this would jeopardize the extinguishing procedure by not allowing the proper concentration of CO<sub>2</sub> to be maintained during the given time. In order to prevent this to happen in some cases some calibrated pressure relief vents are installed. This check-box question is looking for the conditions of the installed units and gave the following result:

**1.15) Do you specify automatic open/close relief vents on the generator housing to relieve excessive inrush extinguishing media pressure?**



This survey has 6 Blank answers – not considered in the graph.

In this case we have 09 Users that do have the described inrush pressure relief vents.

**D 1.16 -**

1.16) What is the maximum number of machines protected by one storage?  
Please specify the extinguishing media:

This question and the following deal with extinguishing media storage characteristics.

This open type question's 1.16 in fact is divided in two parts, as follows:

- Indication of the maximum number of machines protected by one storage,
- Specification of the corresponding extinguishing media

The answers of these two parts were collected in a table as follows:

1.16		Please specify the extinguishing media				
COMPANY	Number per Storage	CO <sub>2</sub>	H <sub>2</sub> O	N <sub>2</sub>	Chem. Powder	Blank
EMP005-SUI	-					1
EMP013-BRA	-					1
EMP051-AUT	-					1
EMP009-JPN	-					1
EMP028-JPN	-					1
EMP037-RUS	-					1
EMP006-SUI	-					1
EMP026-SWE	-					1
EMP019-SWE	1	1				
EMP023-ESP	1	1				
EMP040-NOR	1	1				
EMP056-SUI	1	1	1	1		
EMP010-CAN	11		1			
EMP032-CAN	12		1			
EMP016-BRA	2	1				
EMP025-BRA	2	1				
EMP053-POL	2	1				
EMP045-BRA	2	1				
EMP047-SWE	2	1				
EMP048-GER	2			1		
EMP038-SWE	3	1				
EMP008-BRA	3	1				
EMP054-AUT	4	1				
EMP031-MEX	6	1				
EMP033-NZL	7	1				
EMP015-NZL	8		1			
EMP036-CAN	no limit		1			
EMP027-MKD	4	1				
EMP055-USA	4	1				
EMP058-BRA	4	1				
EMP021-CHN	no limit		1			
EMP039-AUS	no limit		1			
EMP043-JPN	1				1	
EMP020-BRA	1	1				
EMP012-MEX	1	1				
	Total	19	7	2	1	

For water there is no limit of machines per storage as the Australian User, coded EMP039 commented: “No maximum size of supply to meet demand for one unit and manual fire fighting. Redundancy to meet fire NFPA and Australian Fire Codes.” For CO<sub>2</sub> the concepts may vary. We reproduce here the comment of the User from New Zealand, coded EMP033: “7 units, served by an in-service bank of CO<sub>2</sub> cylinders with a spare reserve bank of CO<sub>2</sub> cylinders. The reserve bank is fully connected but requires manual switchover.”

**D - 1.16.1 -**

1.16.1) Do you have main and reserve storage for each group of protected machines?

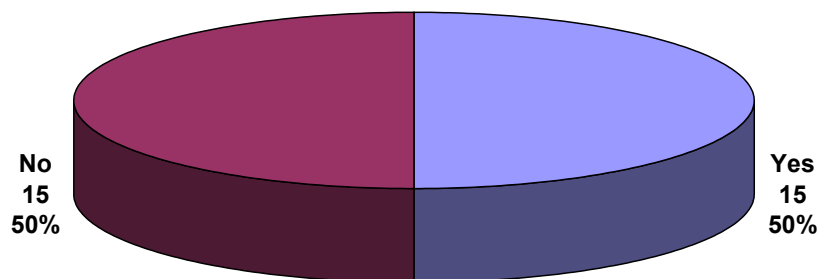
- Yes  - No

If yes, please specify here:

This question was divided in two parts, one as a check-box question and the other as a complement open question for the positive answers.

Starting with the check-box question we have:

**1.16.1) Do you have main and reserve storage for each group of protected machines?**



This survey has 5 Blank answers – not considered in the graph.

Open question analysis results (if yes, please specify here):

The open question for the positive answers of the check-box question resulted in four answers, 03 dealing with CO<sub>2</sub> and one for water. In the case of CO<sub>2</sub> there are answers for “dynamic” back up storage with main and reserve cylinder banks connected to the machine housing by an automatic or manual switchover valves (this allows an additional security degree by means of a “ready to go” back-up storage), as the additional information given by the Brazilian User coded EMP058: “*Normally is used two groups, one reserve of the other.*” Still about CO<sub>2</sub> a peculiar answer was given by the American user coded EMP055 that said: “*Normally the reserve storage is extra bottles in the warehouse.*” In this case no real back-up storage is granted.

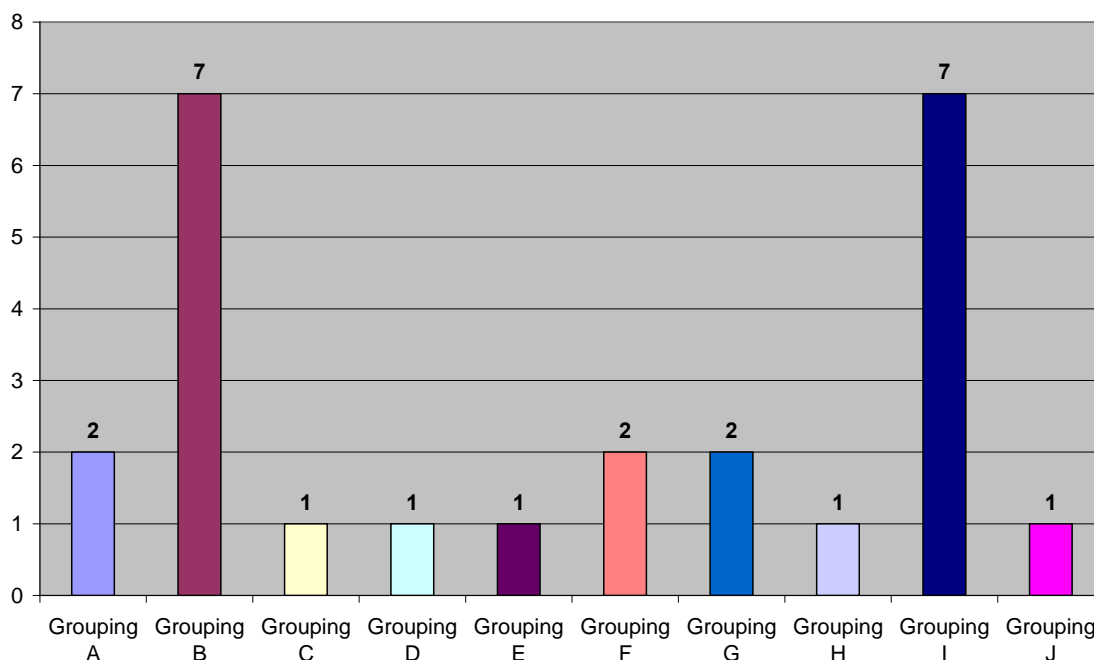
For water as media the following comment was given by the Canadian User, coded EMP010, which uses: “*water storage basins.*”

**D 1.17 -**

1.17) What is the future trend for extinguishing media?

For this open type question we got 26 contributions that were categorized with the following result:

1.17) What is the future trend for extinguishing media?		
Grouping A	CO2 - remains	2
Grouping B	Water - remains	7
Grouping C	Fire extinguisher (dry chemical powder) -remains	1
Grouping D	Foam extinguisher	1
Grouping E	New media like chemical dust, CO2 and halogen composites	1
Grouping F	Inert gas (INERGEN and alike)	2
Grouping G	Inert gas (INERGEN and alike) and water	2
Grouping H	Inert gas, water or none	1
Grouping I	NO fire protection at all	7
Grouping J	NO evolution foreseen	1
Grouping K	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of answered questions</b>		<b>26</b>



Two groups of answers present the tendency in this case. The Grouping B calls for maintenance of water as extinguishing media. The Chinese User coded EMP021 recalls water but is open for new medias as stated in his comment: *“At the moment, we still apply water as a appreciate media. An update media available for environment and no harmful for health is under research and study.”*

The Grouping I calls for no GFP at all, as the Spanish User coded EMP023 reports: *“As it has been mentioned, fire protection systems have been removed according to the generator rewinding program depending on the age of the stator and according to the conditions of the insulation. At the same time of the rewinding process, insulations are renewed using new fireproof materials.”* Here we recall about the still open questions about the alleged fireproof condition of the epoxy based insulations since there are reports of accidents although the unit had this type of insulation, as already stated before.

We call your attention to the statement to the inert gas alternative and water from the Groping G given by an User from New Zealand, coded EMP033: *“Our company’s intention is to maintain CO<sub>2</sub> generator fire protection systems on Meridian’s above ground power stations. For underground power stations Meridian’s intention will be to provide a clean*

agent gas suppression systems such as Inergen or Argonite. In terms of international trends, we see that CO<sub>2</sub> will be phased out due to its harmful affects to personnel, more gas suppression systems will employ gases such as Inergen and Argonite, and more water mist systems will be employed as generator insulation systems become more tolerant to moisture absorption.” A comment here regarding the statement about water mist is that the moisture problem is usually not related to the insulation like such, because it is not difficult to get it dry and the epoxy based insulations are known as water resistant, the major question are the stator core and other components that may be affected by moisture mainly in hard accessible locations.

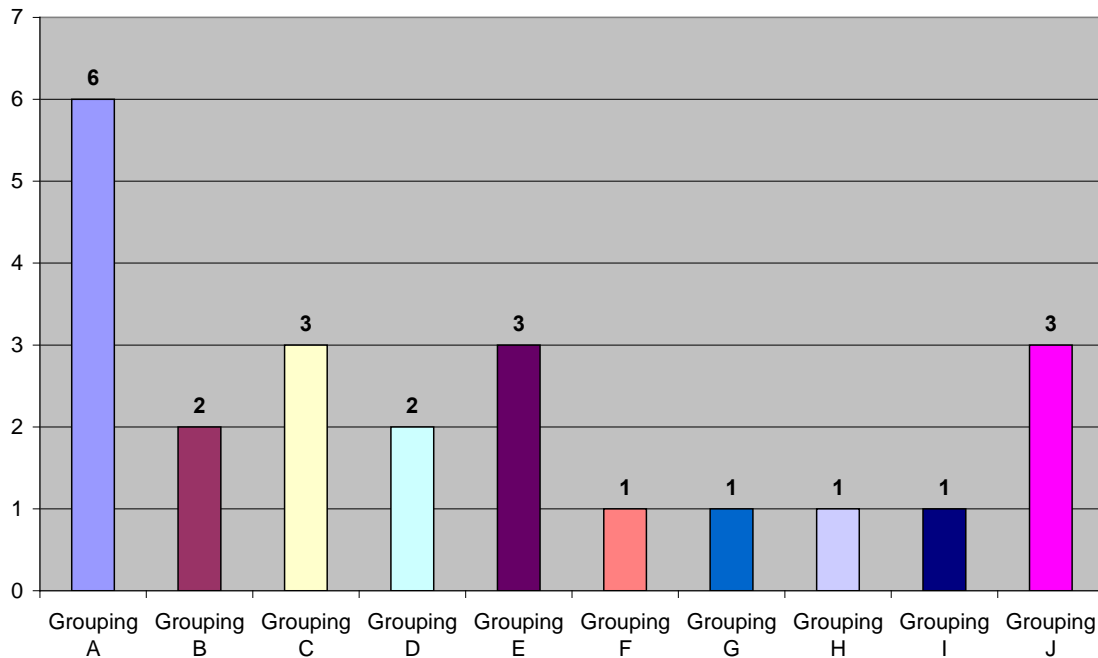
The other comments can be seen on the corresponding annex.

#### D 1.18 - What is the future trend for fire detection?

1.18) What is the future trend for fire detection?

This is a pure open question stated as a brainstorming to gather ideas about future perspectives on the fire detection field, in this case we got 25 contributions that were categorized and the obtained result is the following:

<b>1.18) What is the future trend for fire detection?</b>		
Grouping A	Heat and smoke detectors - remain	6
Grouping B	Advanced smoke detectors (VESDA)	2
Grouping C	Smoke detectors -remain	3
Grouping D	NO perspective of sensor's evolution	2
Grouping E	Combination of detectors and relays monitored by an automatic system (e.g.. artificial intelligence)	3
Grouping F	Chemical analysis of cooling air	1
Grouping G	HAD and split phase	1
Grouping H	Incipient and early detection in combination of heat and smoke	1
Grouping I	Electric arc detection	1
Grouping J	NO detection and NO GFP	3
Grouping K	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of answered questions</b>		<b>25</b>



The grouping A that call for the maintenance of smoke and heat detectors got 6 votes that seems to show a tendency of continuity. As recalled by the Japanese User coded EMP028, that said: *“Same as ever (Smoke and heat).”* There is a group supporting the maintenance of smoke detectors with 3 votes – Grouping C; as the Swedish User coded EMP019 said: *“More smoke detection as a relay protection.”* Also with 3 votes the Grouping E recalls for relays connected via artificial intelligence; this alternative is supported by the Brazilian User coded EMP045 that said: *“It looks that will be the integration of several signs of sensors and electric protections monitored by artificial intelligence (Fuzzy, neural nets).”* This is a real innovative idea. The group that foresees no detection at all and no GFP was evaluated by the Grouping J and also got 3 votes. About this alternative the Spanish User coded EMP023 wrote: *“The trend is the next one: - In new machines there will not be installed any fire extinguishing system. New machines are specified with fireproof materials. Fire detection systems and remote alarm will be installed. -In case of machines with no-fireproof materials, the fire extinguishing systems will be reviewed and will be kept in operation. -In case of machines refurbished with fireproof materials, the already installed fire extinguished systems will be kept, reviewed and maintained in operation.”*

All original comments can be seen on the corresponding annexes.

#### D 1.19 -

1.19) In case of fire, smoke constitutes a major problem on visibility, orientation, breathing capacity, etc. Therefore it is desirable to provide adequate means of combating while involving minimum risk to personnel. In this line please check which additional provisions you do foresee in your plants:

- routine personnel fire fighting and fire escape training
- clearly indicated (illuminated large numbers located low) escape routes
- breathing apparatus (with pertinent use training) or air line system
- emergency lightning located low and personnel own miner type hand lamps
- areas subject to CO<sub>2</sub> clearly indicated, with door interlocks, acoustic and visual alarms
- use of odorized CO<sub>2</sub> only with routine crew recognition training on the fragrance used
- plant ventilation system tested not to recirculate smoke in to the housing in case of fire

- routine check of the generator housing and proper maintenance of openings, doors, etc.
- others, please specify:
- all of the above
- none of the above
- Comments on this issue:

The questions 1.19 and 1.19.1 deal with staff safety and emergency plans.

This item was meant to collect the precautions Users undertake to offer more safety to the involved plant operation personnel. Due to the length of this survey these items were dealt in the form of check-box questions with two correlated open questions. One to explain the alternative “others” and other to comment this issue.

Starting the 1.19 question with the check-box question that will be presented item per item:

<b>Which of these provisions you foresee in your plant:</b>	<b>Votes</b>
Routine personnel fire fighting and fire escape training	28
Clearly indicated (illuminated large numbers located low) escape routes	28
Breathing apparatus (with pertinent use training) or air line system	23
Emergency lightning located low and personnel own miner type hand lamps	24
Areas subject to CO <sub>2</sub> clearly indicated, with door interlocks, acoustic and visual alarms	22
Use of odorized CO <sub>2</sub> only with routine crew recognition training on the fragrance used	09
Plant ventilation system tested not to recirculate smoke in to the housing in case of fire	20
Routine check of the generator housing and proper maintenance of openings, doors, etc	24
Others, please specify: please see below	06
All of the above	07
None of the above	02

As these statistics show almost all of the provisions are being undertaken by a significant number of Users, thus keeping a high degree of safety.

Open question (1) analysis results (others, please specify):

Let's address the “others” alternatives that received the following contributions:

-The User from New Zealand coded EMP033 called for: *“enhanced maintenance and testing to ensure the condition of generator fire protection components and system is maintained and the control and activation system operates correctly.”*

-The Canadian User coded EMP032 called for: *“Manual fire fighting capabilities such as hose-cabinets and hose reel stations.”* Here we would like to point out that in many countries, like Brazil for instance, the generator housing external fire fighting equipment, as hydrants and hose reel stations are defined by the construction code and the Fire Fighting Department in charge.

Open question (2) analysis results (comments on this issue):

To conclude this question we present the results of the open question that asked for comments on this issue. As this is a security issue we present the received comments as follows:

-From the New Zealand User coded EMP015: *“Believe that the warning systems and training that are already in place cover the requirements. Generator fires are generally self extinguishing, and the company policy is that fire fighting is left to the professionals. There are regular trial evacuations and alarms and lighting are checked regularly. If staff is working in dangerous spaces where O2 levels could fall below life sustaining levels they are required to take an escape breathing kit with them.”*

-From the Mexican User coded EMP012: *“Implement the design of the underground power plants in order to make the smoke extraction on the top of the plant’s ceiling. The present extraction nozzles are at the level of the boards.”*

-From the Mexican User coded EMP031: *“Implement monitoring systems and efficient fires smothering.”*

-From the Canadian User coded EMP036: *“In the past, when CO2 was in use, the signs indicated a warning. The indication here is just to share what was used when CO2 was used.”*

-From the New Zealand User coded EMP033: *“Maintenance & testing of older CO2 generator fire protection systems is often overlooked and carried out poorly. Consequently operators, maintainers and technical staff have little confidence that the CO2 systems would work properly when required.”*

-From the Chinese User coded EMP021: *“Special provisions are taken into account as indicated above, the risk to personnel will be reduced to a minimum. Any way, great attention should be paid.”*

#### **D 1.19.1 -**

1.19.1) Additionally to these items the existence on an Emergency Plan, a Fire Brigade and Simulations are very actual, being so please answer the following items:

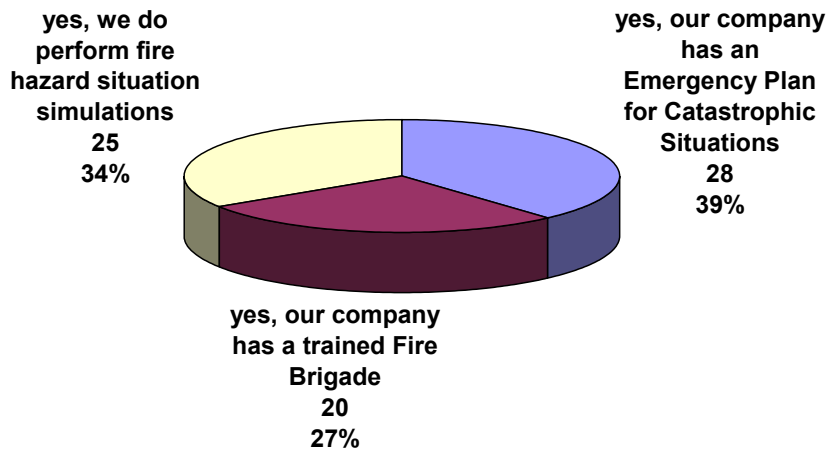
- yes, our company has an Emergency Plan for Catastrophic Situations
- yes, our company has a trained Fire Brigade
- yes, we do perform fire hazard situation simulations                      times a year.

Comments on this issue:

This is a check-box question with two additional extension questions in form of open questions, one asking for the number of hazard simulations performed in a year; and the other is a general request for comments.

Starting with the check-box question we have:

**1.19.1) Additionally to these items the existence on an Emergency Plan, a Fire Brigade and Simulations are very actual...**



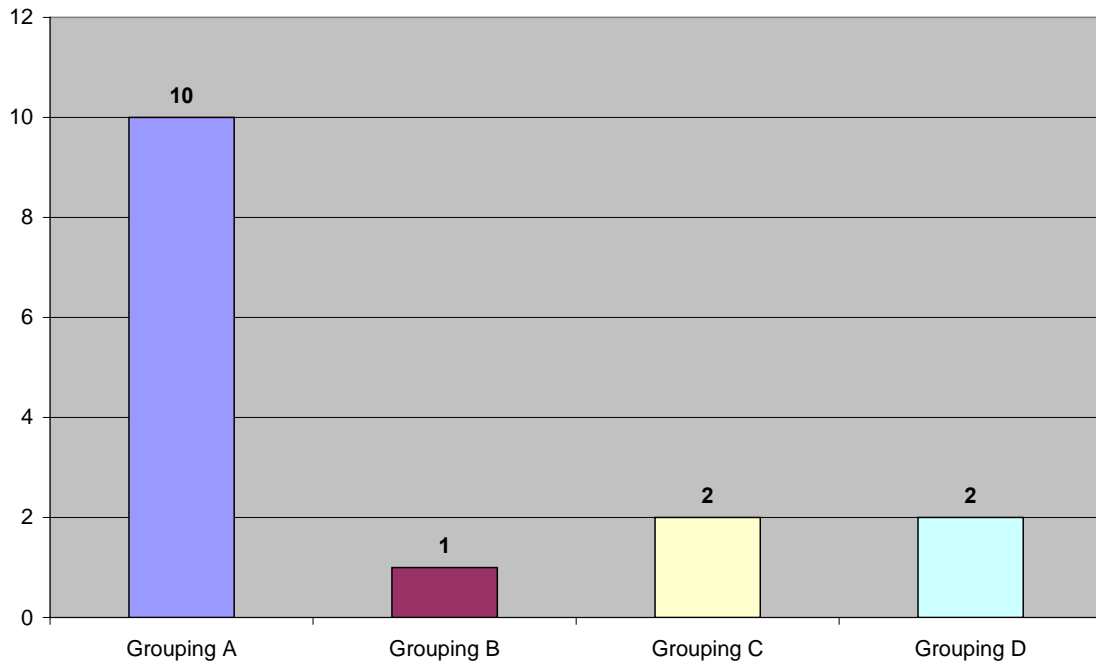
This survey has 1 Blank answer – not considered in the graph.

The results show a high degree of prevention policies undertaken by the Users,

Open question (1) analysis results (yes, we do perform fire hazard situation simulations NN times a year):

The open question regarding the number of hazard simulations made per year received 15 contributions and resulted as follows:

<b>1.19.1) Additionally to these items the existence on an Emergency Plan, a Fire Brigade and Simulations are very actual: yes, we do perform fire hazard situation simulations NN times a year</b>		
Grouping A	One (1) simulation a year	10
Grouping B	Two (2) simulation a year	1
Grouping C	Three (3) simulation a year	2
Grouping D	Unknown	2
<b>Total of answered questions</b>		<b>15</b>

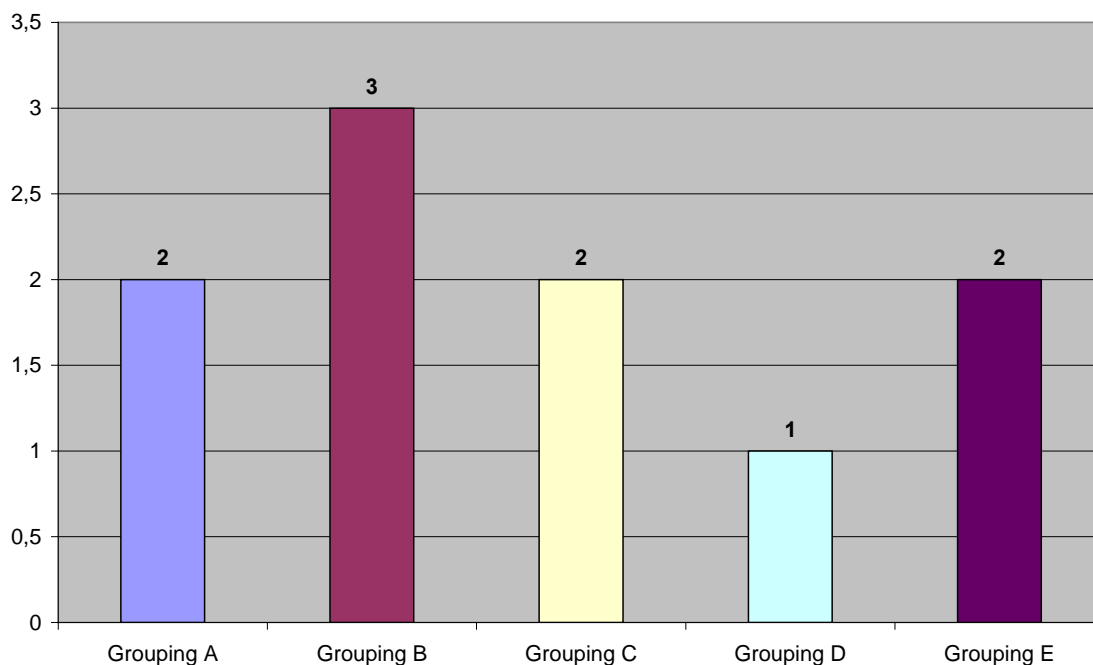


Ten of the 15 Users that answered to this question do perform fire hazard simulations once a year.

Open question (2) analysis results (comments on this issue):

To conclude the item 1.19.1 the open question asking for comments on this issue, here the results of a categorized study:

<b>1.19.1) Additionally to these items the existence on an Emergency Plan, a Fire Brigade and Simulations are very actual: Comment on this issue</b>		
Grouping A	Focus on internal trainings with staff and fire internal brigade	2
Grouping B	Focus on trainings and collaboration with public Firemen	3
Grouping C	Focus on training on emergency conditions, not only fire	2
Grouping D	Responsibility transferred to official Firemen (state owned)	1
Grouping E	Other aspects.	2
<b>Total of answered questions</b>		<b>10</b>



Some additional information given by the Users involved:

-An example of comment for the Grouping A Focus on internal trainings with staff and fire internal brigade given by the Brazilian User coded as EMP045: *“There are trained Fire Brigade to this cases and also internal commissions, to prevent accidents in general (including fire).”*

-An example of comment for the Grouping B Focus on trainings and collaboration with public Firemen given by the New Zealand User coded EMP033: *“Involving fire fighting personnel in regular familiarizations of fire protection equipment and undertake fire drills / simulations is an important aspect to ensure appropriate understanding of equipment and fire fighting procedures.”*

-An example of comment for the Grouping C Focus on training on emergency conditions, not only fire given by the American User coded EMP055: *“Training for all hazards, not just fire hazards.”*

-The comment for the Grouping C Responsibility transferred to official Firemen (state owned) given by the Polish User coded EMP053: *“The Company relies on state-owned Fire Brigade.”*

All original comments can be seen in the corresponding annex.

#### D 1.20 -

1.20) Considering the existence of the recently launched standards (for instance NFPA 851), is there a need of any additional specific international standard on generator fire protection?

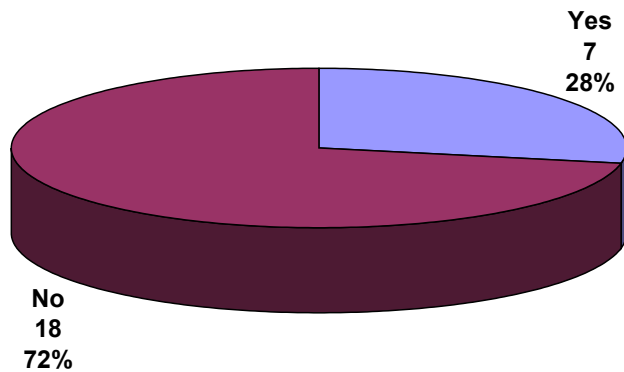
- Yes  - No

Any additional comment? Please state here:

This question was first stated as check-box and there was a call for additional comments which generated an open question.

Starting with the check-box question:

**1.20) Considering the existence of the recently launched standards (for instance NFPA 851), is there a need of any additional specific international standard on generator fire protection?**



This survey has 10 Blank answers – not considered in the graph.

The majority of the Users do not need any additional specific international Standard for GFP.

Open question analysis results (any additional comment?):  
The correlated open question got the following results:

1.20) Considering the existence of the recently launched standards (for instance NFPA 851), is there a need of any additional specific international standard on generator fire protection? Any additional comment? Please state here:		
Grouping A	Published guidelines would be very useful	1
Grouping B	Not yet, the subject has to be discussed in a forum	1
Grouping C	The NFPA 851 Standard is not descriptive enough	1
Grouping D	This subject should be discussed in a special CIGRÉ meeting	1
Grouping E	Not familiar with the indicated standard, has no idea or not considered.	4
Grouping F	Believe that GFP is not necessary	1
Grouping G	Answer does not match the subject asked	2
<b>Total of answered questions</b>		<b>11</b>

From the coherent answers we can reproduce the following comments on this issue:

- The comment for the Grouping A given by the New Zealand User coded : *“Published guidelines would be very useful that recommended suitable generator fire protection schemes based on generator design aspects and generator enclosure design aspects.”*
- The comment for the Grouping B given by the Brazilian company coded EMP013: *“Not yet. The first step is being done and is the creation a forum about the adoption of systems for fire extinction within hydro generators housings in order to discuss its advantages, disadvantages, economic aspects, maintenance and operation.”*
- The following comment for the Grouping C given by the Australian User coded EMP039: *“We felt that it is a high level document and not descriptive enough to make decisions. Our*

fire protection decisions are based on risk (safety, finance, legal, environmental, community standing etc). We have to make decisions on a) whether to have a fire protection or not, b) if fire protection is needed should it be automatic or manual triggering, c) if automatic what should be the triggers, d) guide lines for selecting extinguishing materials etc.”

-The comment for the Grouping D given by the Chinese User coded EMP021: “We propose to organize a special meeting for discussion this topic, or as a routine, this subject will be discussed in the generator group meeting in CIGRE annual meeting.”

#### D 1.21 -

1.21) According to your opinion, is there any question that is missing in this part of the questionnaire?

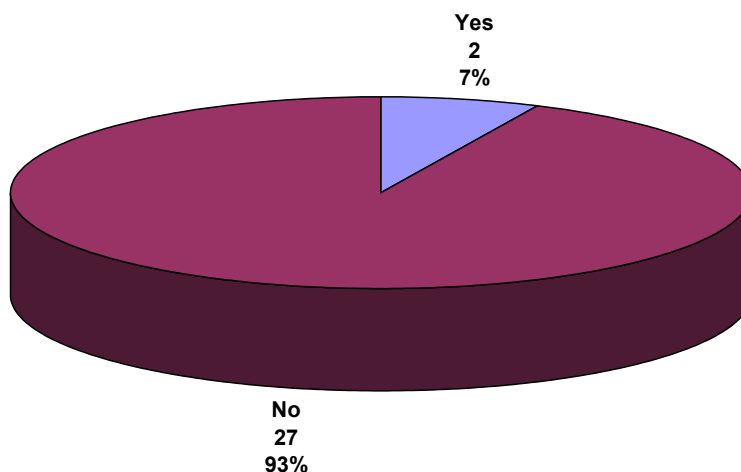
- Yes  - No

If yes, please state it here:

This final question give the opportunity to suggest missing items and was stated in two steps, first a check-box question and for the Yes answers an open question to receive specific suggestions.

Starting with the check-up question:

**1.21) According to your opinion, is there any question that is missing in this part of the questionnaire?**



This survey has 6 Blank answers – not considered in the graph.

As a first result it is possible to say that the participant Users are satisfied with the questions stated with the questionnaire.

Open question analysis results (If yes, please state it here):

On the open question part of this question searching for comments from those who answered yes to the former question we got:

- The comment given by the Brazilian User coded EMP016: *“According to your opinion, is absolutely necessary to install a fire extinguishing system in large hydro generators? (Yes or No) If yes, please specify here why: If no, please specify here why.”*
- The comment given by the Brazilian User coded EMP016: *“For companies that adopt “GFP” should be questioned more about the maintenance and renewal policy of these systems.”*

## E – STUDY OF THE GROUP 2- MANUFACTURERS’ ANSWERS:

This is the third step of this task that got answers of 10 manufacturers that contributed with their valuable participation concerning the **Group 2 - Manufacturers**. We will follow the item numbering of the first part as well as the item numbers of the original Questionnaire (with the numbering correction made in some items) with the prefix “E”. The index of this part of the GFP UPDATE is as follows:

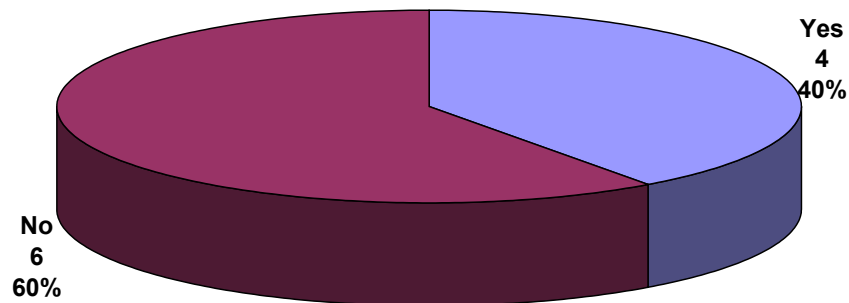
Now passing to the detailed discussion of each item, not forgetting that the pertinent tables with the statistical records of all items are shown in the corresponding annex, we have:

### E 2.1 -

2.1) From the generator manufacturer’s standpoint, do you recommend the use of Generator Fire Protection?  
 - Yes    - No

This is a basic question and shows the Manufacturer’s tendency considering the use of GFP. This question was stated as a pure closed – check-box question, the answers resulted in the following graphic (the corresponding questionnaires and the resulting statistical tables are available in the corresponding annexes):

*2.1) Do you recommend the use of Generator Fire Protection?*



Six out of 10 (60%) of the participant manufacturers do not recommend the use of GFP.

### E 2.1.1-

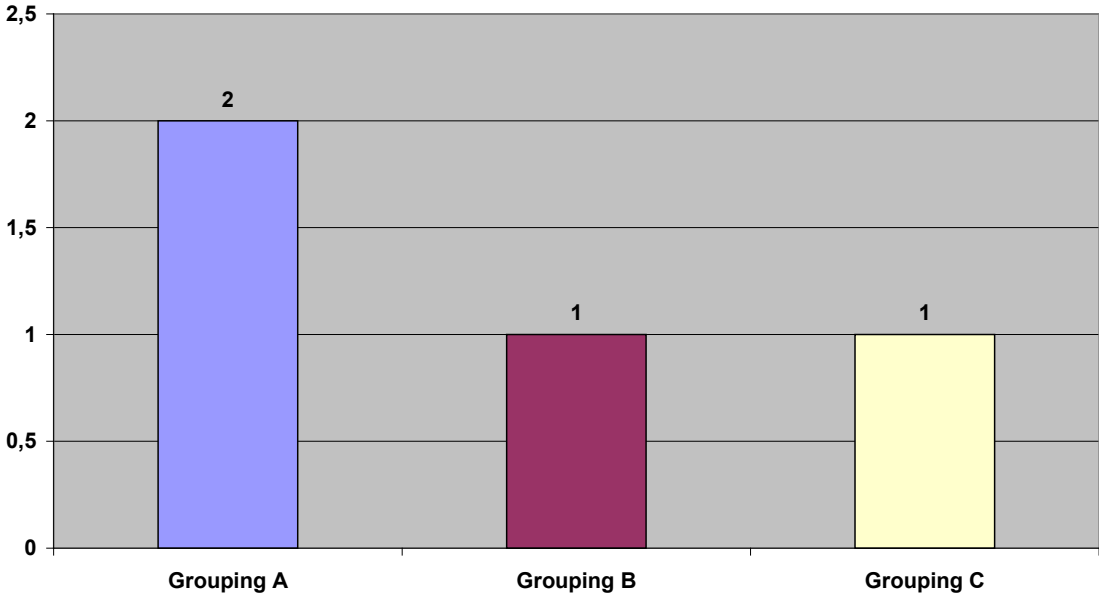
2.1.1) If yes, which type?

This exploratory question was stated as an open question and the results are shown in the analysis below.

We remind that, as an open question allows, we got several different answers which were classified in “**Groupings**” in order to allow a statistical survey on the answers tendency (from time to time we will remind that the original answers as well as the complete statistical tables of the items concerned herewith are available on the corresponding annexes).

2.1.1) From the generator manufacturer's standpoint, do you recommend the use of Generator Fire Protection? If yes, which type?		
Grouping A	CO2	2
Grouping B	Water	1
Grouping C	Depends of Customer's location	1
Grouping D	Blank	6
<b>Total of answered questions</b>		<b>10</b>

2.1.1 - Do you recommend the use of Generator Fire Protection? If yes, which type?



This analysis shows a preference for CO2 systems, but a close look on some answers shows details to be considered:

In the Grouping **C** the Manufacturer EMP001 from Switzerland commented that: “*If acceptable by client we recommend Inergen (Switzerland). For Asia Water spray is preferred then CO2*”. This is in line with the crescent use of Inergen in Europe.

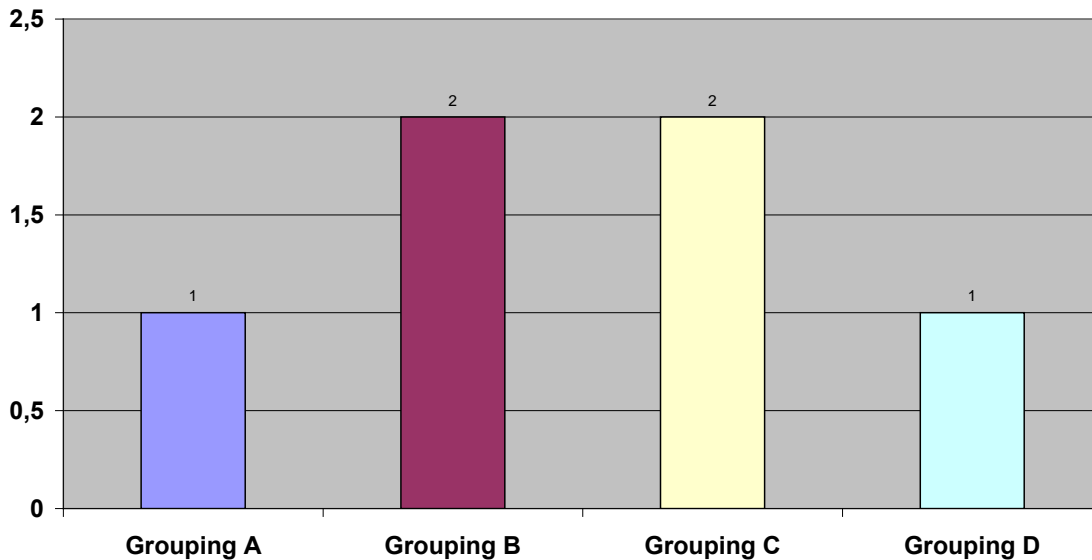
**E 2.1.2 -**

2.1.2) If not, please state your reasons.

This open question allowed making a categorization as follows:

<b>2.1.2) From the generator manufacturer's standpoint, do you recommend the use of Generator Fire Protection? If not, please state your reasons.</b>		
Grouping A	No tradition on using GFP	1
Grouping B	The use o GFP depends upon customer's decision	2
Grouping C	Use of self-extinguishing or non-flammable insulation material	2
Grouping D	State of the art insulation does not avoid risk of damages	1
Grouping E	Blank	4
<b>Total of answered questions</b>		<b>10</b>

**2.1.2- Do you recommend the use of Generator Fire Protection? If not, please state your reasons.**



Here some interesting additional comments were given. Here some of them:

For the Grouping **A** - No tradition on using GFP – the Manufacturer EMP004 from Norway added the following comment: *“There is no tradition for this among our customers. New insulation materials are considered to be self- extinguishable.”*

In the Grouping **B** - The use o GFP depends upon customer's decision - the Canadian Manufacturer EMP050 explained the following: *“All parts of the generator are made of self extinguishing material. The generator is also very sensitively protected by electronic relays as differential earth fault, over current protection, etc. our company is of the general opinion that the fire extinguishing system for generators is a matter between the customer and the insurance company for his machinery.”*

For the Grouping **C** - Use of self-extinguishing or non-flammable insulation material - the comment form the Japanese Manufacturer EMP044 is as follows: *“Self-extinguishing coils are used for our generators.”*

Finally for the Grouping **D** - State of the art insulation does not avoid risk of damages - an Austrian Manufacturer EMP046 wrote the following: *“When using state of the art insulation material risk of major damages is not zero but low. Certain risk of not detecting/wrong detection is still given which would lead to major disturbance in operation.”*

**E 2.2 -**

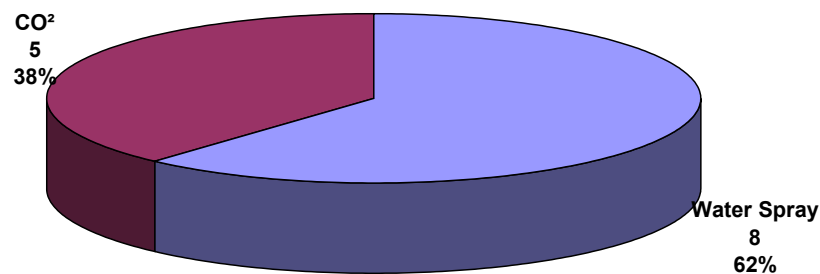
2.2) From your experience, which is the type of generator fire extinguishing method more frequently used nowadays?

- CO<sub>2</sub>
- Water Spray
- Inergen
- Other

If other please specify:

This question has a multiple choice check-box part complemented by an open type complement question. Starting with the check-box part we got the following result:

**2.2 - From your experience, which is the type of generator fire extinguishing method more frequently used nowadays?**



It is interesting to observe that there is a difference between the Manufacturer's perceptions of the more frequently used method and the method they recommend. On the other hand the other alternatives proposed that was Inergen did not receive a mention, but from the Users' side this extinguishing media got several mentions.

Open question analysis results (If other please specify): got no answers.

**E 2.2.1 -**

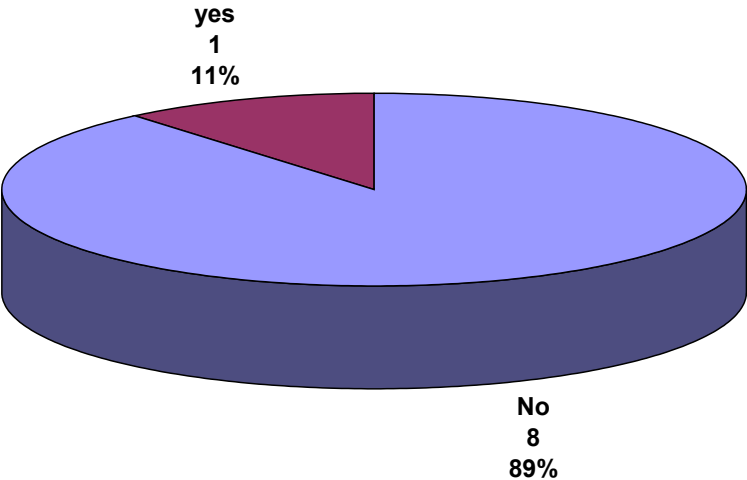
2.2.1) Any change towards the former trend?

- Yes
- No

If yes, please state it here:

This is also a composed question with check-box and exploratory open question. The result of the check-box question's result is the following:

**2.2.1 - Any change towards the former trend?**



Open question analysis results (if yes, please state it here): got one answer from the Japanese Manufacturer EMP044 telling: "Water Spray to CO2"; no other Manufacturer stated a comment.

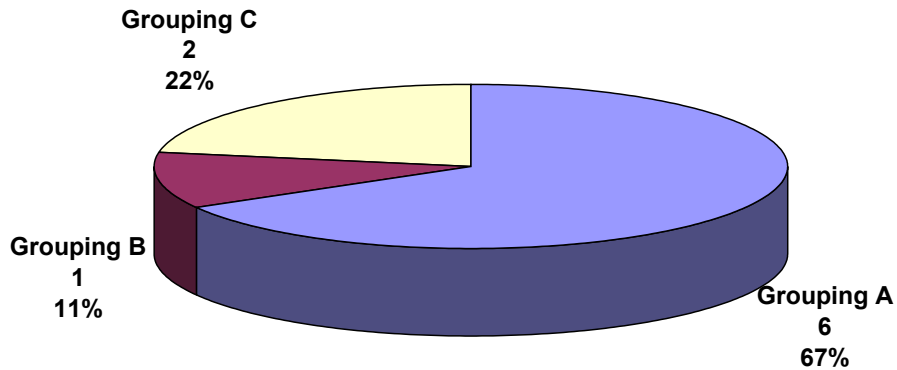
**E 2.3 - Which Standards do you apply in the design of the fire protection of your generators?**

2.3) Which Standards do you apply in the design of the fire protection of your generators?

This is a pure open question that showed the following results:

<b>2.3) Which Standards do you apply in the design of the fire protection of your generators?</b>		
Grouping A	NFPA	6
Grouping B	Countries own Standards (not NFPA)	1
Grouping C	Depends of customer's specifications	2
Grouping D	Not Applicable	1
<b>Total of answered questions</b>		<b>10</b>

**2.3 - Which Standards do you apply in the design of the fire protection of your generators?**



Also for the Manufacturers the American Standards NFPA are the most used.

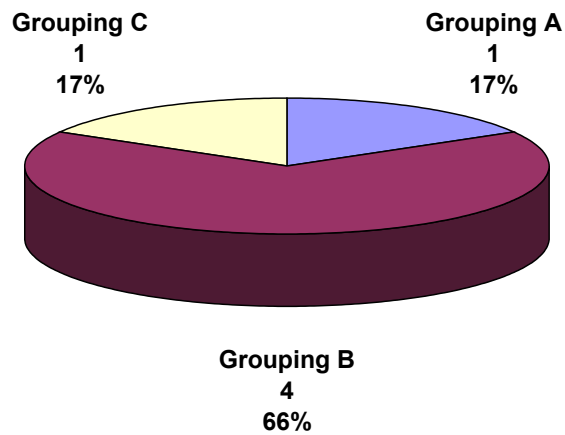
**E 2.3.1 - Are there critical items in the application of these Standards that require special attention?**

2.3.1) Are there critical items in the application of these Standards that require special attention?

This is also a pure open question:

<b>2.3.1) Are there critical items in the application of these Standards that require special attention?</b>		
Grouping A	Correct calculations	1
Grouping B	There are no critical items	4
Grouping C	CO2 in underground stations	1
Grouping D	Not applicable	1
Grouping E	Blank	3
<b>Total of answered questions</b>		<b>10</b>

**2.3.1 - Are there critical items in the application of these Standards that require special attention?**



On the Grouping **A** - Correct calculations – the Manufacturer EMP001 from Switzerland called the attention for: *“Correct computation of required water flow.”*  
On the Grouping **C** - CO<sub>2</sub> in underground stations – the Manufacturer EMP046 from Austria reminded that: *“CO<sub>2</sub> systems are always critical in underground stations, therefore should be avoided in such applications.”*

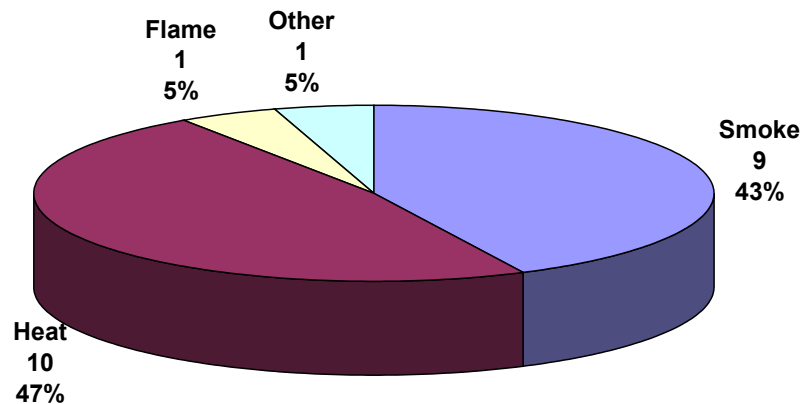
**E 2.4 -**

2.4) What is the state of the art in the detection in accordance to your experience?

- smoke
- heat
- flame
- other – please describe:

This is a check-box type question with an “other” alternative that results in an open question. The check-box question resulted in the following graphic:

**2.4 - What is the state of the art in the detection in accordance to your experience?**



Open question analysis results (other-please describe here): only one Manufacturer, in this case the French company EMP003 pointed out the following: “In general we energize the fire protection only if two types of detectors are activated (smoke and temperature) or if smoke detector (or temperature detector) is activated at the same time as the electrical differential protection.”

**E 2.4.1 -**

2.4.1) Which are the types of detection devices you normally use and/or recommend?

This is a pure open question and all answers converged to “smoke and heat” detectors and here some of the comments are reproduced; the complete comments can be seen on the corresponding annex:

The French Manufacturer coded EMP003 commented the following: “*smoke detectors or temperatures detectors. Only one type of detector is not the signature of fire presence (temperature detector can be activated at stand still when the cooling is stopped, smoke detectors can be activated by presence of dust, especially*”.

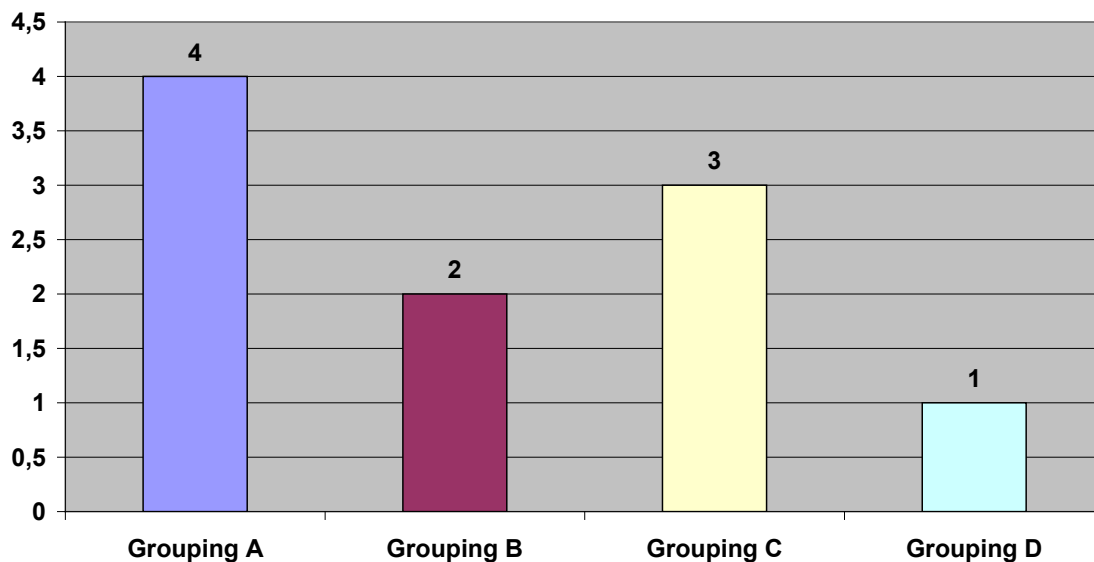
**E 2.4.2 -**

2.4.2) Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation?

This is a pure open question and the answers allowed a categorized analysis which resulted as follows:

<b>2.4.2) Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation?</b>		
Grouping A	Smoke and Thermal plus protection relay	4
Grouping B	Use different type of detectors	2
Grouping C	Nothing special	3
Grouping D	Depends on customer's decision	1
<b>Total of answered questions</b>		<b>10</b>

**2.4.2 - Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation?**



This question was pointed out by the Users as one of their greatest concerns due to the implications inherent to risk situation to operators and to property caused by unwanted operation (release) of the GFP equipment. The Manufacturers show that they are aware of this issue and some offered their suggestions. Although the complete answers are available on the annex here a selection of the received answers:

On the Grouping A (Smoke and Thermal plus protection relay) got 4 answers and we point out the Chinese manufacturer EMP021 that wrote: "The fire extinguishing system will be released in case of:

- a) Some of settling smoke detectors actuated;
- b) Some of settling heat detectors actuated;
- c) Differential and or neutral protection already tripped off;
- d) Circuit breaker of high voltage side of main transformer and de-escalation breaker already tripped off."

This is a very complete position and is the trend of combined sensors and interlocking with the generator's electrical protection.

On the Grouping B (Use different type of detectors) the Canadian Manufacturer coded as EMP050 commented the following: "2 different types of detectors in series to avoid false detection".

The Grouping C (Nothing special) did not show any special comment, this group is composed by Manufacturers that do no issue recommendations.

On the Grouping D (Depends on customer's decision) the Austrian Manufacturer, coded EMP046, commented the following: *“Applied system mainly depends on customer's overall plant fire protection philosophy.”*

## E 2.5 -

2.5) Does your company design generators suited to any of the existing fire extinguishing media (CO<sub>2</sub>, Water Spray, Halon substitutes, etc.), or there are limitations from your side?  
 - No limitations  - Yes, there are some limitations

The answers received 9 answers “No limitations” only the Japanese Manufacturer coded EMP044 selected the “Yes, there are some limitations” alternative. Thus from the Manufacturer’s side there should be no problems with the use of water as extinguishing media, but it is known that stator core corrosion may appear some time after the use of water. Not forgetting the pole laminations that may also be affected by water.

### E 2.5.1 -

2.5.1) Should you have limitations, please state them here:

This exploratory open question, as expected had only one answer from the Japanese Manufacturer EMP044, that stated the following: *“In case of gas type fire extinguishing media such as CO<sub>2</sub> or Halon is applied, air tightness of the generator housing is required by customers.”* We add to this concern the question related to the inrush pressure during the CO<sub>2</sub> short time deployment – in this case it may be that special pressure relief openings have to be installed in order to avoid damages in the housing openings to keep the same sound in order not to be torn away; by this means the required CO<sub>2</sub> concentration during the specified time can be guaranteed.

## E 2.6 -

2.6) From the fire protection standpoint, the generator and its housing have to be considered as a whole in the design when fire extinguishing is to be installed, in order to guarantee the system’s functionality and efficiency. Considering this fact are you always informed by the purchaser from the beginning of the generator’s design of the future application of a specific generator fire protection method?  
 - Yes  - No

Any comments? Please state them here:

This question is a two stages one, at first one check-box question then an open question requesting for comments.

The check-box part showed that in this case only the Norwegian Manufacturer coded EMP004 answered with “NO”, this shows that the majority of clients do inform the use of

GFP at the beginning of the project, this transfers some responsibility to the Manufacturers.

Open question analysis results (Any comments? Please state them here): we got two answers as follows:

The Swiss Manufacturer coded EMP001 explained that: *“Generally yes, but not with enough details.”*

And the French Manufacturer coded EMP003, explained that: *“generally the fire protection is in the scope of the generator manufacturer (for new installation) and design of the capacity of fire protection depends directly on the size of the generator.”*

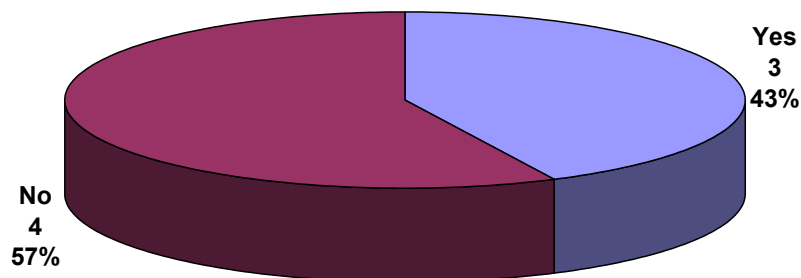
### E 2.6.1 -

2.6.1) Are you requested to participate in the definition of the fire extinguishing system to be applied in one generator of your manufacture?

- Yes  - No

Any comments? Please state them here:

#### **2.6.1 - Are you requested to participate in the definition of the fire extinguishing system to be applied in one generator of your manufacture?**



This question had 3 blank answers.

Open question analysis results (Any comments? Please state them here):

Again two additional explanations were received, as follows:

The French Manufacturer, coded as EMP003, stated: *“My answer is Yes as the fire protection is generally in the scope of the generator manufacturer but it is also No if not in the scope it is rarely stated what will be the generator fire protection in the future.”*

The Austrian manufacturer, coded as EMP046, stated that: “Sometimes we are involved, sometimes the system is already defined by the customer”

### E 2.6.2 -

2.6.2) Did you have to adapt a ready generator design to a specific fire extinguishing system?

- Yes  - No

If yes, when:

- before manufacture

- during manufacture

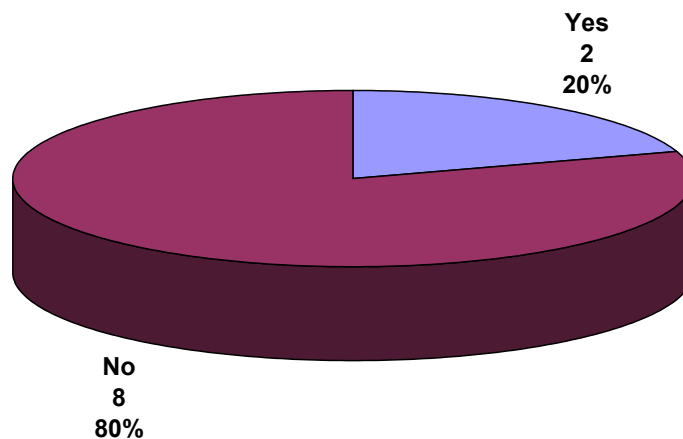
- after erection?

Any comments? Please state them here:

This question was stated in three stages: two check-boxes and one explanatory open question.

First check-box question (Yes or No): gave the following result:

#### **2.6.2 - Did you have to adapt a ready generator design to a specific fire extinguishing system?**



Second check-box question (alternatives: before manufacture, during manufacture and after erection): gave the following result: two Manufacturers, the Swiss coded EMP001 and the Austrian coded EMP046 checked the answer: “before manufacture”; it means the design was ready and had to be altered in order to comply with a late notice about the GFP installation.

Open question analysis results (Any comments? Please state them here): we got three contributions, as follows:

The Swiss Manufacturer, coded EMP001, explained the following: *“It is recommended to coordinate the needed piping system with the pipes and cables of all other auxiliary components at an early stage of the project.”*

The French Manufacturer, coded EMP003, added the following explanation: *“We adapt the fire extinguishing system to the dimensions of the generator.”*

And the Canadian Manufacturer, coded EMP050, wrote: *“CO2 and Halon need special requirements for the housing and bearings (pressure on both sides of the sump).”*

## E 2.7 -

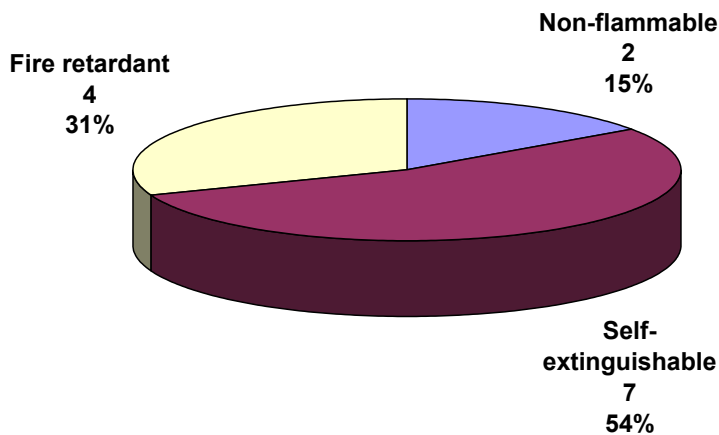
2.7) Modern insulation materials are mostly considered to be non-flammable, fire retardant or self-extinguishable. Since these aspects are subject to test conditions that sometimes diverge from actual accident situations, please check how the insulation material you use can be classified:

- flammable
- non-flammable
- fire retardant
- self-extinguishable

Any comments? Please state them here:

This question is composed by a check-box part and an exploratory question. Starting with the check-box question, a multiple choice between the following alternatives: flammable, non-flammable, fire retardant and self-extinguishable. The result is as follows:

### 2.7 - How the insulation material you use can be classified?



In this case three Manufacturers checked two categories each, as follows:

- The American company coded EMP057 indicated: fire retardant and self-extinguishable.
- The Chinese manufacturer coded EMP021 indicated: non-flammable and fire retardant.
- The Austrian Manufacturer coded EMP046 indicated: fire retardant and self-extinguishable.

More details can be seen on the corresponding annex.

In fact none of the participant Manufacturers indicated flammable; this indicated that all do use modern type insulation material, but it may be that these manufacturers are not sticking to the concepts that are stated in the corresponding standards.

Here it may be interesting to point out some technical aspects concerning this particular subject. Let's start with some brief definitions according to former classification:

**Non-flammable:**

Material that exposed to source of heat, direct flame or incandescent resistance does not come into combustion.

**Self-extinguishable:**

Material that exposed to source of heat, direct flame or incandescent resistance bursts into flame, which in a certain time (usually in seconds) is extinguished.

**Fire-retardant:**

Material that exposed to source of heat, direct flame or incandescent resistance bursts into flame is not extinguished but the speed of burning is minimized.

Talking about insulation, Class F 155 ° C and Class H 180 ° C are only the temperatures of insulating materials in rotating machines under continuous operation; they do not have any necessary relation to flammability. The flammability characteristics are defined by the material used and is specified, for instance, in standards as NEMA, ASTM, IEC and test standard as UL under defined circumstances.

The new flammability classification is defined by the CEI IEC INTERNATIONAL STANDARD 60893-3-2 revision 2003-11, and also in a similar way by the UL94 Flammability Standard. The classification normally applied to hydro generators is the "V-0" grade (that stands for Vertical Testing grade "0" – there are grades for Horizontal Testing for other purposes). The V-0 requires the following from the testing probe:

- Specimens must not burn with flaming combustion for more than 10 seconds after either test flame application.
- Total flaming combustion time must not exceed 50 seconds for each set of 5 specimens.
- Specimens must not burn with flaming or glowing combustion up to the specimen holding clamp.
- Specimens must not drip flaming particles that ignite the cotton.
- No specimen can have glowing combustion remain for longer than 30 seconds after removal of the test flame.

On the "Table 5- Property requirements" of the CEI IEC INTERNATIONAL STANDARD 60893-3-2 revision 2003-11, the different material conditions are described. This includes the "Flammability Category". For instance for the material coded "EP CP 201", "EP GC 202" and "EP GC 204" EP= Epoxy, CP= Cellulosic paper, GC= Woven glass cloth and so on the flammability is defined as V-0, but an important note is added concerning the flammability indication:

QUOTE

*The small-scale laboratory test used in this standard for assigning a flammability category is primarily for monitoring consistency of production of laminates. **The results so obtained should not in any circumstances be considered as an overall indication of the potential fire hazards presented by these laminates under actual conditions of use.***

UNQUOTE

No manufacturer is allowed to state that their machines are “*non flammable*” due to the fact that they use V-0 grade insulating components. The Standards do not allow this type of statement. But in the mean time a myth was created about machines being non flammable, and this situation is leading many Users to skip the use of any GFP in their plants. Manufacturers that proceed this way may become liable towards their customers in the case of a fire accident.

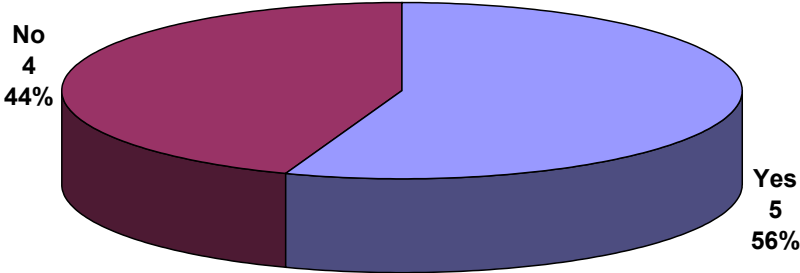
Open question analysis results (Any comments? Please state them here):  
Only the Chinese Manufacturer coded EMP021 commented that: “*As the reasons above, we recommend not to install the fire extinguishing device for small and medium*”

**E 2.7.1 -**

2.7.1) Do you test the flammability conditions of the materials you use by yourself?  
 - Yes    - No  
If not, who does these tests for you and under which conditions?

This is a combined question, starting with the check-box part (Yes/No) we got the following graphic:

**2.7.1 - Do you test the flammability conditions of the materials you use by yourself?**



The Chinese Manufacturer coded EMP021 did leave this question blank.

Open question analysis results (If not, who does these tests for you and under which conditions?):  
In this case we got two comments, they are the following:  
-The Norwegian Manufacturer coded EMP004 said: “*No specific tests performed*”.

-The Austrian Manufacturer coded EMP024 explained that: *“Internal tests and also tests by various external institutes.”*

## E 2.8 -

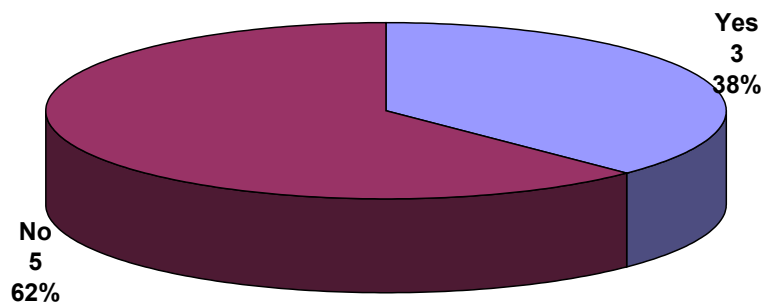
2.8) Has any of the hydro generators you manufactured suffered a fire accident?

- Yes  - No

If yes, please state some details here:

This is a combined question, and the result of the check-box (Yes/No) part is shown in the graphic:

**2.8 - Has any of the hydro generators you manufactured suffered a fire accident?**



Two Manufacturers did not answer leaving the check-boxer unmarked.

Open question analysis results (If yes, please state some details here) resulted in two contributions:

-The Norwegian Manufacturer coded EMP004 told the following: *“Several incidents due to electrical faults”*

-The Austrian manufacturer coded EMP046, explained: *“Happened more than 15 years ago.”*

From this side we got little information about fire accidents seen from Manufacturer’s perspective.

**E 2.8.1 -**

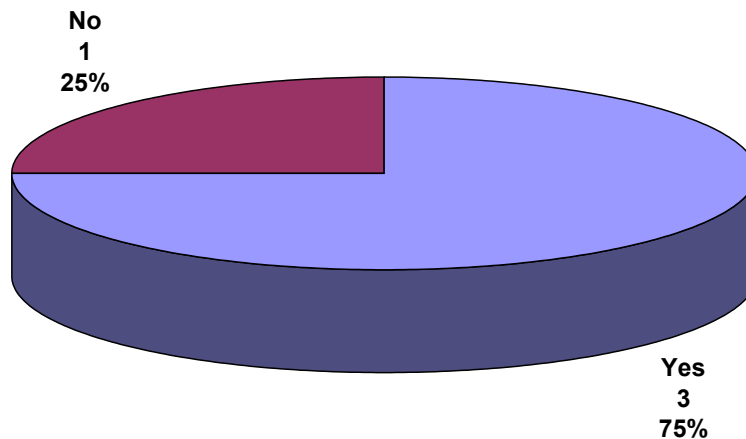
2.8.1) Was the origin of the fire determined?

- Yes  - No

If yes, please state some details here:

The check-box part of this question resulted in the following graphic:

**2.8.1 - Was the origin of the fire determined?**



In this case six Manufacturers left the check-boxes unmarked.

Open question analysis results (If yes, please state some details here), we got three results, as follows:

-The Swiss Manufacturer coded EMP001 explained that: *“Generator circuit breaker was did not operate correctly. Generator remained connected to grid and excitation was turned off. The machine was operating in inadmissible asynchronous mode.”*

-The Norwegian Manufacturer coded EMP004 wrote: *“Short-circuits, earth faults”*

-The Austrian Manufacturer coded EMP046 , wrote: *“Origin in overloaded soft-soldered winding connections.”*

**E 2.8.2 -**

2.8.2) Was the generator equipped with fire protection system?

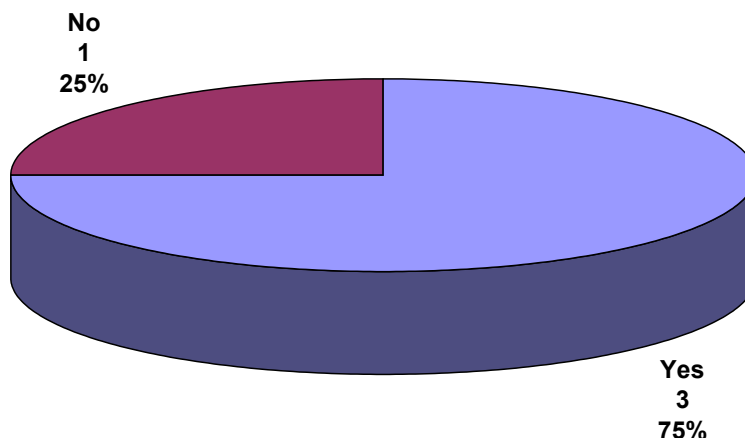
- Yes  - No

If yes, please state which type here (CO<sub>2</sub>, water-spray, etc.):

Following the four Manufacturers that are following this tread because they reported an fire accident in one of their supplied machines we have this combined check-box and auxiliary open question.

The check-box question gave the following result:

**E 2.8.2 - Was the generator equipped with fire protection system?**



Remembering: 6 Manufacturers did not participate at this stage.

Open question analysis results (If yes, please state which type here - CO<sub>2</sub>, water-spray, etc.): the Swiss Manufacturer coded EMP001 and the Austrian Manufacturer coded EMP046 reported that the generators were protected with CO<sub>2</sub>, the Norwegian Manufacturer coded EMP004 left his answer blank and the Japanese Manufacturer coded EMP044 answered N.A that does not make much sense in this particular case.

**E 2.8.2.1 -**

2.8.2.1) Do you know if it did work properly?

- Yes  - No

If yes, please state some details here:

This is also a combined question and the check-box part (Yes/No) had the following answers: The Swiss Manufacturer coded EMP001 and the Japanese Manufacturer coded EMP044 answered "Yes" and the other two, the Norwegian coded EMP004 and the Austrian coded EMP044, answered "No", the other six remained out of this question too.

Open question analysis results (If yes, please state some details here) the only answer received was from the Swiss Manufacturer, coded EMP001, that answered : "*The system*

worked properly. However the cause of the fire was not eliminated. After some time, the CO2 had vanished and the generator restarted to burn.”

### E 2.8.3 -

2.8.3) Do you have any specific comment and/or information about the damages that occurred?

This is a pure open question and no categorized survey was possible, but the received answers are important because they transmit a practical experience. This answers are:

- The Swiss Manufacturer coded EPM001 explained that: “*Further equipment in the power station got damaged.*”
- The Norwegian Manufacturer coded EMP004 explained that: “*Fire extinguishes when electrical fault is disconnected, however, lots of smoke, and power station must be evacuated for a long time*”
- The Austrian Manufacturer coded EMP046 explained that: “*We have discontinued the use soft soldered connections about 15 years ago.*”
- The Japanese Manufacturer coded EMP044 indicated N.A. again.

### E 2.8.4 -

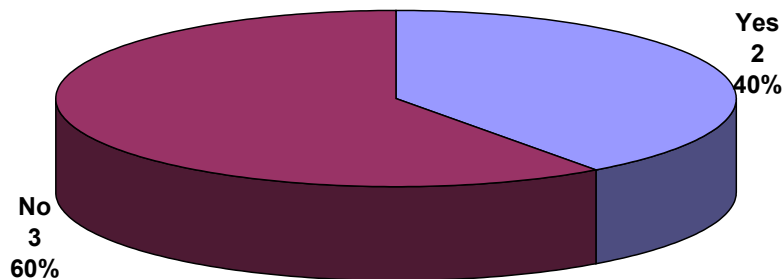
2.8.4) Would you like to state a general recommendation considering generator fire protection?

- Yes  - No

If yes, please state it here:

This is a combined question, and the check-box result is the following:

**2.8.4 - Would you like to state a general recommendation considering generator fire protection?**



The other five manufacturers did not check a box.

Open question analysis results (If yes, please state it here) and we got two important contributions:

-From the Austrian Manufacturer coded EMP046: *“Clean conditions, state of the art insulation material, a proper ventilation system, brazed winding connections are essential for safe operation. Fire protection is recommended for old generators (old insulation systems, soft soldered connections, etc.)”*

-From the Canadian Manufacturer coded EMP050: *“Fire extinguishing is not required. Are recommended: fire detection, fire resistant doors.”*

## E 2.9 -

2.9) Besides the design and production of new generators, does your company participate in the refurbishment and/or maintenance area?

- Yes  - No

If yes, please state some details here:

This is a combined question and the check-box part showed the following result: nine Manufacturers answered ‘Yes’ and on did not check any box.

Open question analysis results (If yes, please state some details here): as answer four Manufacturers confirmed that they are also active in the refurbishment field. More details can be seen on the corresponding annex.

## E 2.9.1 -

2.9.1) If yes, does it include the fire extinguishing systems?

- Yes  - No

If yes, please state some details here:

This is a combined question. On the check-box (Yes/No) part four Manufacturers answered “Yes”.

Open question analysis results (If yes, please state some details here): we got the following answers:

-The French Manufacturer coded EMP003 said: *“Generally the fire protection system is already installed in the power station, sometimes we are asked to refurbish it.”*

-The Japanese Manufacturer coded EMP034 said: *“Replacement of existing fire extinguishing system”*

-The Canadian Manufacturer coded EMP050 said: *“Sometimes in major rehabs”*

**E 2.10 - According to your opinion, is there any question that is missing in this part of the questionnaire?**

2.10) According to your opinion, is there any question that is missing in this part of the questionnaire?

- Yes  - No

If yes, please state it here:

This is a combined question. The check-box (Yes/No) part got 8 answers "No" and two Manufacturers left blank.

Open question analysis results (If yes, please state it here): since there was no answer "Yes" no answer on the check box part, no answer was stated on the open question part.

## **F - STUDY OF THE GROUP 3- INSURERS' ANSWERS:**

This is the fourth step of this task that got answers of 5 Insurance Companies that contributed with their valuable participation concerning the **Group 3 – Insurance Companies, Reinsurance Companies or Insurer Brokers**.

It was not easy to get these contributions and they are considered in spite of being only five companies that agreed upon to answer to our questionnaire. We have to point out that none of them is a CIGRÉ member; therefore they did not have any obligation to help this work whatsoever. Their completely volunteer contributions are very important to understand the point of view of one major player in the decision chain that leads to the use of GFP to protect Hydro Generators. Herewith we express our gratitude for this participation.

We include herewith for the sake of better understanding all answers related to this group. We will follow the item numbering of the first part as well as the item numbers of the original Questionnaire with the prefix "F". The index of this part of the GFP UPDATE is as follows:

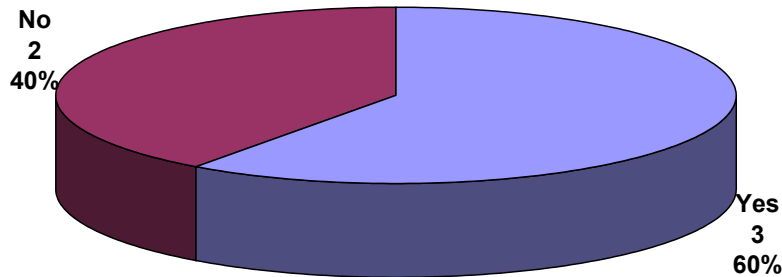
Now passing to the detailed discussion of each item, not forgetting that the pertinent tables with the statistical records of all items are shown in the annex, we have:

### **F 3.1 -**

3.1) Is fire protection for hydro generators required from a plant owner to insure a power plant?  
 - Yes    - No  
If yes, please state some details here:

This is a combined question, check-box with complement open question. The check-box part showed the following:

**3.1 - Is fire protection for hydro generators required from a plant owner to insure a power plant?**



Open question analysis results (If yes, please state some details here): Although the number of answers is little we made graphics to speed up the reading of the results, that in this way can be seen in a glance.

Grouping	Legend	Quantity
Grouping A	GFP recommended or required	2
Grouping B	At least detection	1
Grouping C	Blank	2
<b>Total of answered questions</b>		<b>5</b>

The explanations given constitute the richer part of the contributions given by the Insurance companies, so we present them as follows:

For the Grouping A (GFP recommended or required):

-The American Insurer coded EMP018, explained that: *“Fire protection is generally recommended for hydrogenerators. Gaseous extinguishing systems and water spray systems are the recommended solutions.”*

- The Chinese Insurer coded EMP021, explained that: *“The fire protection insurance required from the customer is based on the requirement of our National fire security regulation and specifications.”*

For the Grouping B (At least detection):

- The German Insurer coded EMP022, explained that: *“at least fire detection relayed directly to the fire brigade”* are required.

**F 3.1.1 -**

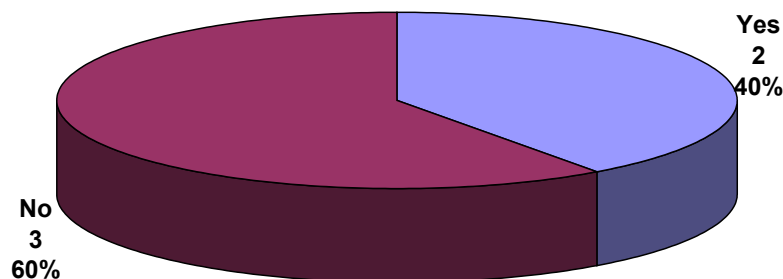
3.1.1) Does the requirement of fire protection depend upon the size of the units or any other factors?

- Yes  - No

If Yes, which are the factors you use to apply?

The check-box part of this question (Yes/No) showed the following result:

**3.1.1 - Does the requirement of fire protection depend upon the size of the units or any other factors?**



Open question analysis results (If Yes, which are the factors you use to apply?), for this explanatory question we got two answers:

-The American Insurer coded EMP018, explained that: *“The replacement value of the unit as well as its criticality (i.e. the monetary value associated with not being able to generate electricity) is considered.”*

- The German Insurer coded EMP022, explained that: *“Power and number of units in 1 fire area.”* This is a risk assessment parameter.

**F 3.1.1.1 -**

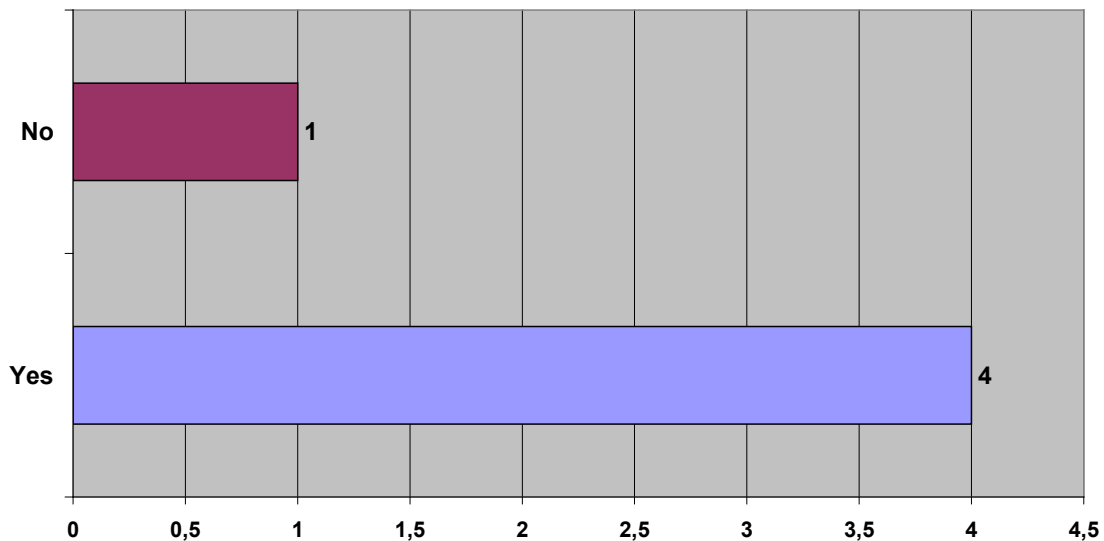
3.1.1.1) Do you require any kind of special supervisory technical equipment to be installed on the machines you cover the risk as for instance stator and runner temperature supervision/monitoring?

- Yes  - No

If Yes, which are they, please comment?

The check-box part of this question showed the following situation:

**3.1.1.1 - Do you require any kind of special supervisory technical equipment to be installed on the machines you cover the risk as for instance stator and runner temperature supervision/monitoring?**



Open question analysis results (If Yes, which are they, please comment), this additional question complements the question above and resulted in the following additional information:

-The American Insurer coded EMP018, explained that: *"In addition to the IEEE recommended generator electrical protection, we also recommend thermal detectors under the top cover of the hydrogenerator and/or embedded in the windings as well as photoelectric smoke detectors or a very early warning fire detection system to active the fire protection system. We also recommend that a "lock-out" relay be installed to prevent the generator being re-energized without a proper investigation as to why the electrical protection operated."*

- The Chinese Insurer coded EMP021, explained that he requires: *"Smoke and heat detector."*

- The German Insurer coded EMP022, requires: *"Full state of the art condition monitoring."*

- The Swedish Insurer coded EMP052, explained that: *"Temperature monitoring for windings in rotor and stator, as well as vibration monitoring."*

**F 3.1.2 -**

3.1.2) Do you follow any standards or you have your own rules to deal with hydro generators?

- Yes  - No

If yes, please state some details here:

The check-box part of this question had the following result:

EMP018 (United States)	Yes
EMP021 (China)	Yes
EMP022 (Germany)	Yes
EMP024 (Norway)	No
EMP052 (Sweden)	Yes

The question was stated to find out how many insurance companies do follow own Standards; the exploratory question throws more light to it.

Open question analysis results (If yes, please state some details here), as the answers will show the involved Insurers did not focus on the difference between using own Standards or existing ones:

- The American Insurer coded EMP018, explained that: *“We follow IEEE standards, NFPA standards as well as our own FM Global standards.”*
- The Chinese Insurer coded EMP021, explained that: *“The standards we strictly follow are made by National (Chinese) fire extinguishing commission.”*
- The German Insurer coded EMP022, informed that uses: *“own standards developed with power companies.”* This is a step forward since there is the Users participation in the establishment of the Insurer’s operating rules.
- The Swedish Insurer coded EMP052, explained that he uses: *“Standards and partly own guidelines.”*

### F 3.1.2.1 -

3.1.2.1) What are the factors that imply in a reduction of hydro generators fire risks?

This is a pure open question and the information passed by the Insurers is very important and interesting; it may serve as guideline for cost-minded users:

- The American Insurer coded EMP018, explained that: *“Replacement value, criticality, combustible loading, electrical protection, fire protection, and operating conditions. Other factors such as the age of the machine and whether the station is normally attended also play a part.”*
- The Chinese Insurer coded EMP021, explained that: *“The factors are, for example, quantity of main parts manufacturing and erection, inspecting and maintenance operation and commissioning of unit as well as the high attention to foreseen fire risk and personnel fire training.”*
- The German Insurer coded EMP022, informed that the important points are: *“Condition monitoring, fire protection (turbine oil systems; generator; cable routes), fire load through oils, fire separation.”*
- The Norwegian Insurer coded EMP024, explained that he requires: *“Automatic fire detection systems and fire extinguishing systems.”*
- The Swedish Insurer coded EMP052, explained that : *“Loss prevention: service and maintenance. Operation risk: automatic extinguishing systems.”*

**F 3.2 -**

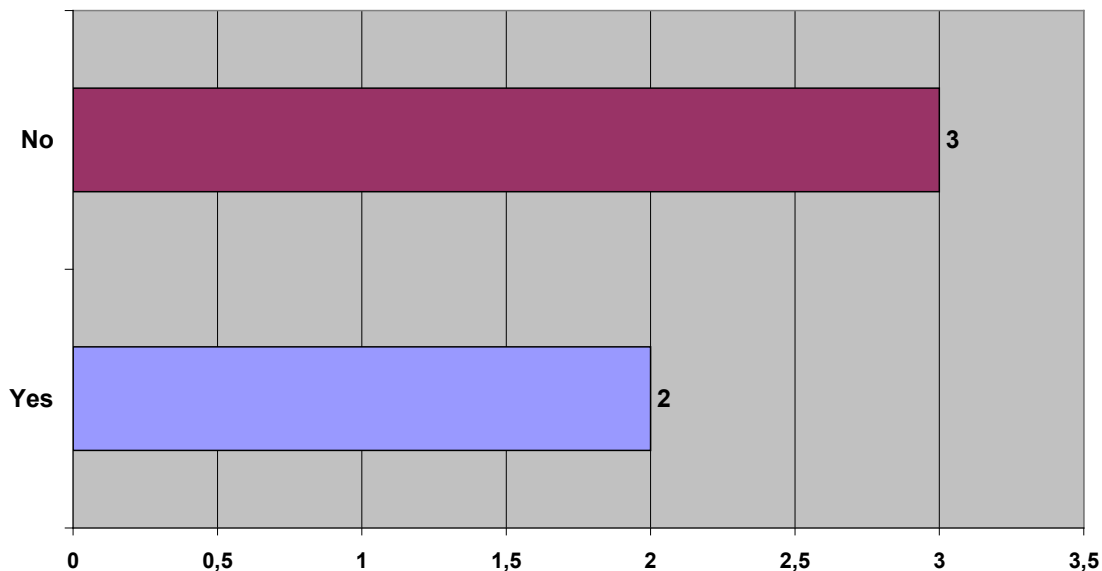
3.2) Does your company have preference for or recommends any one of the existing generator fire extinguishing methods?

- Yes  - No

If yes, please specify here:

The check-box part of this question has the following result:

**3.2 - Does your company have preference for or recommends any one of the existing generator fire extinguishing methods?**



Open question analysis results (If yes, please specify here), the two Insurers that answered yes stated their answer as follows:

-The American Insurer coded EMP018, explained that: “*We recommend either water spray or gaseous fire suppression systems.*”

- The German Insurer coded EMP022, recommends: “*Inert gas (e.g. CO2) and sprinkler.*”

**F 3.3 -**

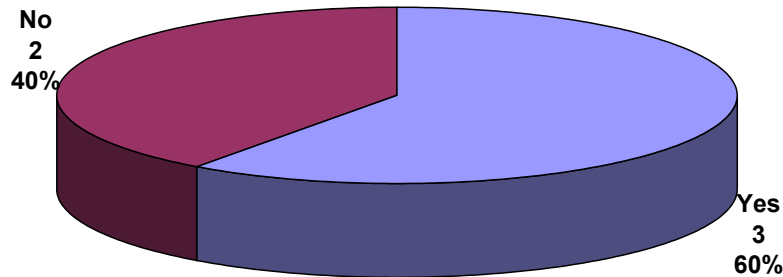
3.3) Is there a policy of insurance cost reduction depending upon the type of fire protection scheme the user installs?

- Yes  - No

If yes, please specify here:

This composed question shows the following result for the check-box part:

**3.3 - Is there a policy of insurance cost reduction depending upon the type of fire protection scheme the user installs?**



This result shows that the practice of cost reduction in case of use of certain type of GFP is common among the insurance companies. In our universe the majority does it.

Open question analysis results (If yes, please specify here); since we had three answers “Yes” here are the corresponding additional explanations:

- The American Insurer coded EMP018, explained that: *“This is company confidential information which we cannot share in detail. However in general terms, FM Global underwrites based on the quality of risk. Fire protection is one aspect of determining risk quality.”*
- The German Insurer coded EMP022, referred to a former item, as follows: *“see 3.1.2.1.: Condition monitoring, fire protection (turbine oil systems; generator; cable routes), fire load through oils, fire separation.”*
- The Swedish Insurer coded EMP052, explained that this grants a: *“Fire premium reduction”*

**F 3.3.1 -**

3.3.1) Is there any requirement from your side concerning maintenance of the fire fighting equipment and power plant’s personnel fire training?

- Yes  - No

If yes , please specify here:

This is an important issue considering that in many cases the maintenance of the GFP equipment is neglected this not allowing it to work properly when necessary.

The check box part of this question showed the following result: all five Insurers answered “Yes”.

Open question analysis results (If yes, please specify here); the details were given by the participant Insurance Companies, as follows:

- The American Insurer coded EMP018, explained that: *“FM Global has requirements for routine inspection and testing of fire protection systems. We also have requirements for training of power station personnel in emergency response.”*
- The Chinese Insurer coded EMP021, explained that: *“Normally, after the completion of generator installation e together with the fire fighting organization and the customer have a detailed inspection for the measures and the equipment, protection system and other related facilities.”*
- The German Insurer coded EMP022, informed that the important points are: *“Based on international standards (CEA, VdS, NFPA,...).”*
- The Norwegian Insurer coded EMP024, explained that he requires: *“Yearly: Maintenance / control of fire extinguishing equipment + fire training if more than 40 employees.”*
- The Swedish Insurer coded EMP052, explained that: *“According to Swedish Standards.”*

#### **F 3.3.1.1 -**

3.3.1.1) If you answered the last item (3.3.1) with yes do you verify if you customer is attending to the requirements of maintaining the equipment properly and keeping the personnel trained?

- Yes  - No

If yes , please specify here:

The check-box part of the question showed that all participant Insurers do verify the compliance with maintenance and personnel training, with exception of the Chinese Insurer that answered “No”.

Open question analysis results (If yes, please specify here), in accordance with the check-box answers we got four comments, as follows:

- The American Insurer coded EMP018, explained that: *“FM Global engineers visit power stations on a routine basis to verify that fire protection equipment is being tested and maintained. And if the personnel is regularly trained.”*
- The German Insurer coded EMP022, explained that: *“We check documentation of tests and trainings.”* This is an “believe-type” verification, because it relies on paper work confirmation, instead of field checking.
- The Norwegian Insurer coded EMP024, explained that: *“Verified during our inspections.”*
- The Swedish Insurer coded EMP052, explained that: *“Certificates and Questionnaires.”*

#### **F 3.4 -**

3.4) Did you have any claim of refund of damages caused by isolated hydrogenerators fire in the last 30 years?

- Yes  - No

This pure check-box question (Yes/No) starts a sequence of questions that got important answers based upon real accident situation reported. The result achieved is the following:

Company	Result
	Answer
EMP018 (United States)	Yes
EMP021 (China)	No
EMP022 (Germany)	Yes
EMP024 (Norway)	Blank
EMP052 (Sweden)	No

### F 3.4.1 -

3.4.1) If yes, please give the basic available data (Plant, Country, Quantity of affected generators, year of the fire, etc). Should several examples be available please feel free to give the data in a table.

A table was made in order to allow the information of several accidents, thus enlarging the experience gathering of this survey. The following questions, up to the question F 3.4.5 , do consider the multiple information received. The question F 3.4.1 is a pure open question and the answers received are as follows, and show the Insurers perspective regarding this type of accidents:

-The American Insurer coded EMP018 used the table and presented five complete examples that are identified by Gen 01 to Gen 05:

Gen 01	<p>130 MVA unit</p> <p>Electrical protection cleared a stator fault.</p> <p>Fire protection did not activate because the temperature in the generator housing did not reach a sufficiently high level.</p> <p>The unit was returned to service in about a week.</p>
Gen 02	<p>2 x 130 MVA units.</p> <p>In two separate and unrelated incidents, stator insulation failure ignited the insulation of two different generators.</p> <p>Fire protection operated and controlled the fire. The fire protection was activated by temperature detectors in the generator housing.</p> <p>The units were repaired and returned to service in 3 months.</p>
Gen 03	<p>280 MVA unit</p> <p>Electrical protection operated due to stator insulation failure and cleared the fault.</p> <p>Fire protection operated because stator winding temperature was high. The heat was generated by the electrical fault. The insulation did not catch on fire.</p>

	<p>Approximately 10 sq m of stator was damaged.</p> <p>The unit was returned to service after 6 months</p>
Gen 04	<p>170 MVA unit</p> <p>Unit was in a planned outage.</p> <p>Smoke from welding operating activated water spray protection</p> <p>Unit was not dried.</p> <p>After the outage the unit was placed in service several days later and it suffered a stator insulation breakdown.</p> <p>The generator had to be dried and 36 stator coils were removed for repairs.</p> <p>The unit was returned to service after 3 months.</p>
Gen 05	<p>130 MVA unit</p> <p>Fire occurred in stator end turn insulation.</p> <p>Smoke activated water spray system and controlled fire.</p> <p>Damaged coils were repaired.</p> <p>Unit was air dried for 24 hours and returned to service in 3 days</p>

- The German Insurer coded EMP022 reported accident with two units, the first two are related to the same unit in different conditions:

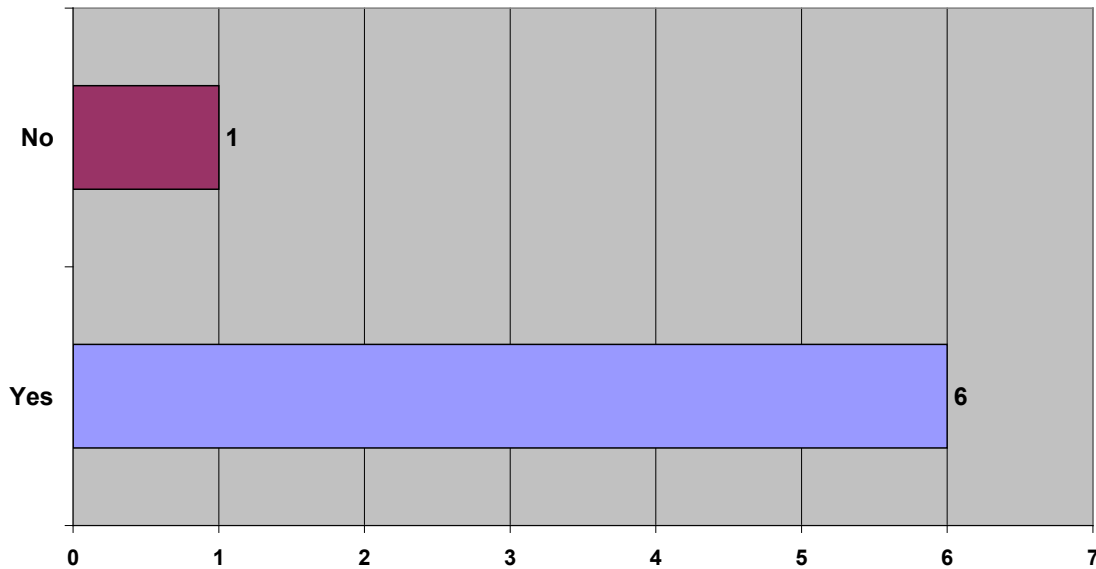
Gen 01(a)	In 1995 there was no protection on the generator, resulting in a €10 Mio loss
Gen 01(b)	After the loss in this unit a CO2-protection was installed with manual release - the second loss in 2000 resulted in a €1,5Mio loss as the CO2-protection was released with a delay of 200 minutes - today the system has automatic release - up to now no further loss, but estimates are below €0,2Mio.
Gen 02	In the 1990s there was a total loss of a 60 MW generator in a cavern in Sweden - no further details are known

#### F 3.4.2 -

3.4.2) If yes, can you specify if the damaged plant had generator fire protection installed?  
 - Yes    - No

For this pure check-box question the following result was achieved:

**3.4.2 - If yes, can you specify if the damaged plant had generator fire protection installed?**



The “No” answer is related to the accident reported under Gen 01(a) by the German Insurer that in the first stage had no GFP installed. But after the installation of the GFP the decision was taken to rely on manual release; and when a second accident occurred the long time of 200 minutes (>than 3 hours!) to trigger the GFP release still caused a major damage to the unit. Now the release was changed to automatic.

**F 3.4.2.1 -**

3.4.2.1) If yes, did fire protection work properly during the accident?  
 - Yes    - No  
 Any additional comment and or information?

The check box part of this combined question result is displayed below. Due to the structure of the answers the indication with the evaluation table may give a better understanding:

Insurance Company	Gen Units	Result
		Answer
EMP018 (United States)	Gen 01	Yes
	Gen 02	Yes
	Gen 03	Yes
	Gen 04	Yes
	Gen 05	Yes
EMP021 (China)		Blank
EMP022 (Germany)	Gen 01(a)	Blank
	Gen 01(b)	No
	Gen 02	Blank
EMP024 (Norway)		Blank
EMP052 (Sweden)		Blank

Again the blank on the Gen 01(a) reported by the German Insurer stands for the fact that initially the unit had no GFP installed.

Open question analysis results (Any additional comment and or information?) the answers are reach in details and for the sake of better understanding the compilation table is shown below:

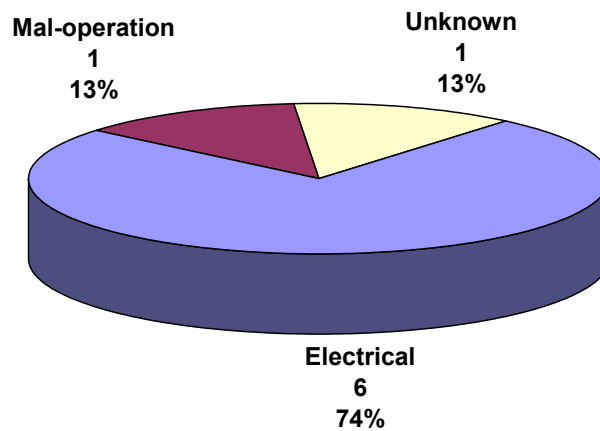
Insurance Company	Gen Units	Result
		Answer
EMP018 (United States)	Gen 01	Although fire protection did not operate, it was not designed to operate if electrical protection is able to clear the fault and prevent a fire from developing.
	Gen 02	Blank
	Gen 03	Even though there was no actual fire, the fire protection system was considered to have operated properly because it was designed to operate when the stator winding temperature exceeded a certain level.
	Gen 04	Fire protection worked as designed but this was a mal-operation because the fire protection was operated by smoke generated by welding and not an actual fire.
	Gen 05	Today the system has automatic release - up to now no further loss, but estimates are below €0,2Mio.
EMP021 (China)		Blank
EMP022 (Germany)	Gen 01(a)	2 losses 1995 and 2000 in the same unit in Germany - therefore the mention to Gen 1(a) and Gen 1(b) to indicate that the comments do refer to the same machine in two different times.
	Gen 01(b)	Blank
	Gen 02	Blank

### F 3.4.3 -

<p>3.4.3) If yes, is it possible to inform the alleged cause of the fire?</p> <p><input type="checkbox"/> - electrical</p> <p><input type="checkbox"/> - mechanical</p> <p><input type="checkbox"/> - influence from outside the generator housing</p> <p><input type="checkbox"/> - other...</p> <p>Any additional comment and or information?</p>
---

The check-box part offered the following alternatives: electrical, mechanical, influence from outside the generator housing and other... And we got the following result:

**3.4.3 - If yes, is it possible to inform the alleged cause of the fire?**



The “mal-operation” alternative is related to the smoke-sensor that reacted to the smoke of a soldering machine; in this case it is to check if the GFP is to be kept sharp during maintenance works or if other solution has to be taken under these circumstances. The “unknown” alternative (left blank in the questionnaire) is related to the accident that occurred in the nineteenth reported by the German Insurer – for which no detail was available any more.

Open question analysis results (Any additional comment and or information?) this part of the question did not receive any comment.

**F 3.4.4 -**

<p>3.4.4) Was there any consequential damage to other units or to other equipment installed outside the generator housing?</p> <p><input type="checkbox"/> - Yes   <input type="checkbox"/> - No</p> <p>Any additional comment and or information?</p>
--

The answers received for his check-box part (Yes/No) were given only by the American Insurer that informed that in none of the five accidents he reported a consequential damage occurred. The other did not mark any check box which resulted in blank answers.

Open question analysis results (Any additional comment and or information?) this part of the question did not receive any comment.

**F 3.4.5 -**

3.4.5) Was the refund paid?

- Yes  - No

If not, what were reasons that impeached the payment after your due diligence on the fire itself?

Closing this very interesting section of questions and answers, in which the American Insurer made a significant contribution to this work, we have the following answers to the check-box part (Yes/No):

The refund was paid for all five accidents reported by the American Insurer and the three informed by the German Insurer.

Open question analysis results (If not, what were reasons that impeached the payment after your due diligence on the fire itself?) this part of the question did not receive any comment, because all refunds were paid.

**F 3.5 -**

3.5) According to your opinion, is there any question that is missing in this part of the questionnaire?

- Yes  - No

If yes, please state it here:

For the check-box part (Yes/No) or this control question we got the following situation:

Company	Result
	Answer
EMP018 (United States)	No
EMP021 (China)	No
EMP022 (Germany)	No
EMP024 (Norway)	Blank
EMP052 (Sweden)	Yes

Open question analysis results (If yes, please state it here); we got one interesting contribution that can be taken as a goal for any further development of this work:

The Swedish Insurer EMP052 suggested the following items for a further discussion: "Risk estimation factors like maintenance/overhaul, Intermittent operation (faster aging, wear and tear), Education (operation personnel) and Outsourcing (service/maintenance)"  
These are interesting aspects concerning the Insurers perspective.

## G – STUDY OF THE GROUP 6- CONSULTINGS’ ANSWERS:

This is the fifth step of this task that got answers of 9 Consulting Companies that contributed with their valuable participation concerning the **Group 6 – Consulting Companies**. Considering the possibility that the Consulting Companies invited to participate were not acquainted with the CIGRE’s type of survey the following text was included to this group’s questionnaire:

### QUOTE

*This questionnaire is an UPDATE in which this particular section is dedicated to the **Consulting Companies** that usually issue at least the project specification for the Generator Fire Protection. As already stated before in our opinion from the fire protection standpoint, the generator and its housing have to be considered as a whole in the design when fire extinguishing is to be installed, in order to guarantee the system’s functionality and efficiency integrated in the concept of the power plant as a whole. With these questions we intend to get valuable information from the particular stand point of the **Consulting Companies** in order to compose a picture as complete as possible of the subject we are dealing with to see if the opinions do converge or not to the same point.*

### UNQUOTE

We include herewith for the sake of better understanding all answers to the corresponding questionnaire’s questions related to this group. We will follow the item numbering of the first part as well as the item numbers of the original Questionnaire with the prefix “G”.

Now passing to the detailed discussion of each item, not forgetting that the pertinent tables with the statistical records of all items are shown in the corresponding annex, we have:

### G 6.1 -

6.1 - Is your company specialized in the design of the Generator Fire Protection:

- Isolated (only the equipment itself)
- Integrated in the power plant design
- Whole power plant design including the Generator Fire Protection

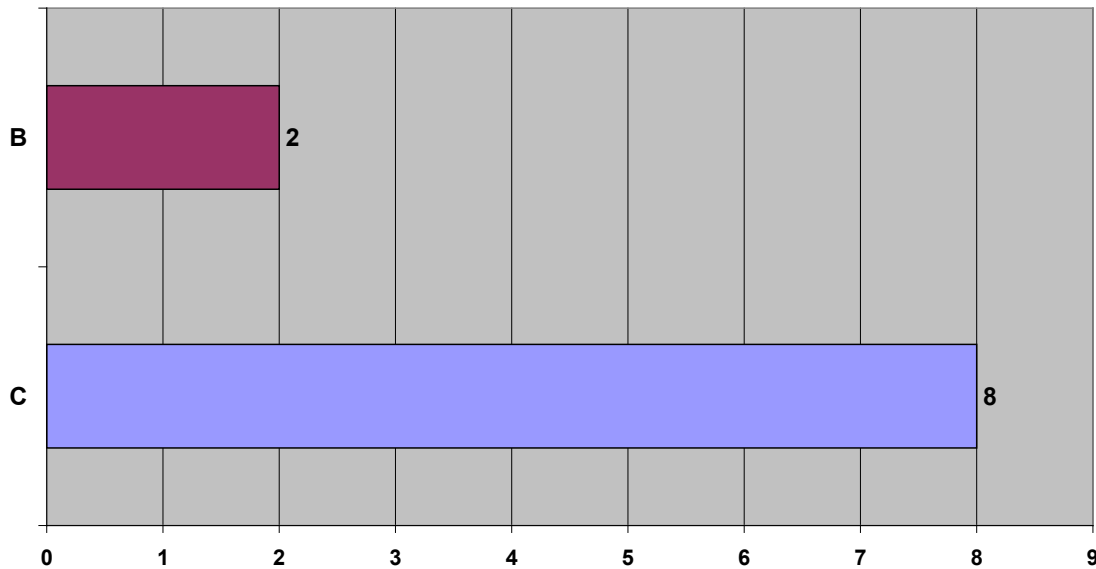
Any comment on that?

The check- box part of this combined question offered 3 alternatives, as follows, a categorization was made in order to allow a graph to be made (long alternative names):

Category	Description
A	Isolated (only the equipment itself)
B	Integrated in the power plant design
C	Whole power plant design including the Generator Fire Protection

The statistics showed the following graph:

**6.1 - Is your company specialized in the design of the Generator Fire Protection?**



The German Consultant coded EMP030 ticked the categories “B” and “C” therefore the sum of votes is 10. The alternative “A” was not marked.

Open question analysis results (Any comment on that?): in this case we got three comments, as follows:

-The English Consultant coded EMP035, explained that: *“Mott MacDonald are involved in carrying out feasibility studies and preparing performance specifications for hydro power plant.”*

-The Swedish Consultant coded EMP041, explained that: *“Our Company does not design GFP’s. Generally the whole power plant layout is supported”*

-The Swedish Consultant coded EMP049, explained that: *“Fire extinguishing systems are normally only used for old generator types (Bitumen) and oil-filled transformers in underground position. Fire detection systems and evacuation of fire gases are installed in the plant.”*

**G 6.1.1 -**

6.1.1 - Should you work specifically with the Generator Fire Protection Equipment (not as a power plant designer) in which moment of the power plant’s project are you normally engaged by your customer:

- bid stage (in order to get the data for the Generator Fire Detection’s specs)
- after the generator supplier was already defined
- in a stage when your expertise will be taken in to consideration in the whole project including the required civil work for the proper adaptation and safe function of the Generator Fire Protection
- None of the above, please specify:

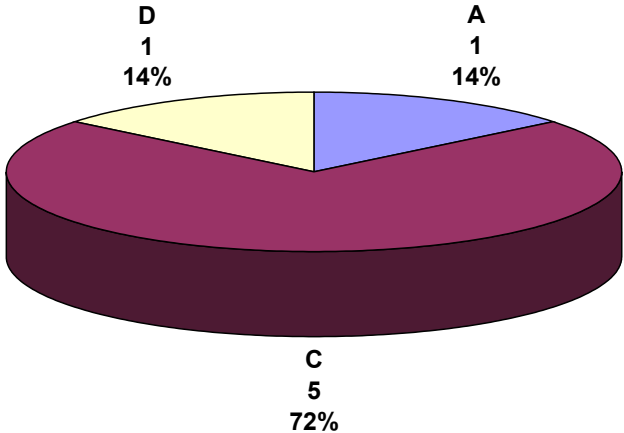
Any comment on that?

The check- box part of this combined question offered 4 alternatives, as follows, a categorization was made in order to allow a graph to be made (long alternative names):

Category	Description
A	Bid stage (in order to get the data for the Generator Fire Detection's specs)
B	After the generator supplier was already defined
C	In a stage when your expertise will be taken in to consideration in the whole project including the required civil work for the proper adaptation and safe function of the Generator Fire Protection
D	None of the above, please specify:

The statistics showed the following graph:

**6.1.1 - Should you work specifically with the Generator Fire Protection Equipment (not as a power plant designer) in which moment of the power plant's project are you normally engaged by your customer:**



In this case two Consulting Companies did not make a selection.

Open question 1 analysis results (None of the above, please specify:) This exploratory question was answered only by the English Consulting coded EMP035 that did mark the alternative "" on the check-box part with "none of the above" and now answers to the request to specify it: *"Mott MacDonald would not normally work with generator fire protection specifically. Our involvement would be within the overall generator specification and our involvement would commence in a general way during a feasibility study and then in more detail"*

Open question 2 analysis results (Any comment on that?) This exploratory question got no answers.

**G 6.2 -**

6.2) There are the factors (or reasons) that lead your clients to order a Generator Fire Protection project from your company. According to your experience, considering these factors, who decides if the generators have to be equipped with Generator Fire Protection?

- The customer that place the order to you (not necessarily the final user – it may be the integrator)

- The insurance companies that demand it towards the final user in order to cover the power plant's risk

- The final user that may earn financial advantages towards the insurer by installing such a protection and requires it either directly or via integrator.

- Power plant workers Labor Union Demands towards the final users

- Final users' own internal philosophy

- You are asked to give an advice/opinion

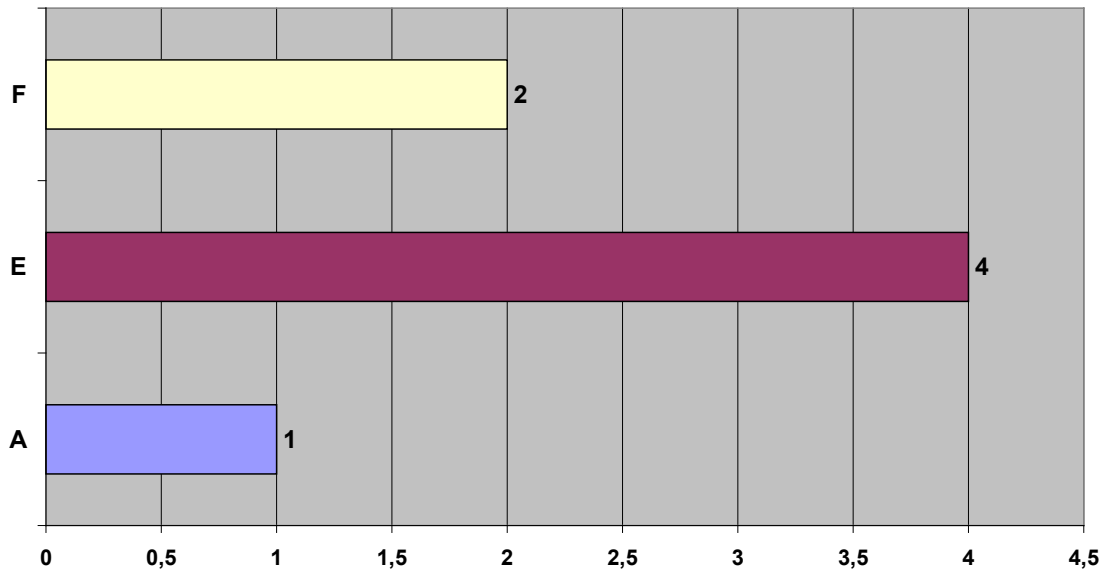
Any comment on that?

The check- box part of this combined question offered 6 alternatives, as follows, a categorization was made in order to allow a graph to be made (long alternative names):

<b>Category</b>	<b>Description</b>
A	The customer that place the order to you (not necessarily the final user – it may be the integrator)
B	The insurance companies that demand it towards the final user in order to cover the power plant's risk
C	The final user that may earn financial advantages towards the insurer by installing such a protection and requires it either directly or via integrator.
D	Power plant workers Labor Union Demands towards the final users
E	Final users' own internal philosophy
F	You are asked to give an advice/opinion

The statistics showed the following graph, in which only the categories A, E and F were selected by the involved Consulting:

**6.2 - According to your experience, considering these factors, who decides if the generators have to be equipped with GFP?**



From the Consulting point o view it is more often that the use of GFP depends upon the “Final users’ own internal philosophy”.

Open question analysis results (Any comment on that?): in this case we got three comments, as follows:

-The Swiss Consultant coded EMP011, explained that: *“Our Consulting Company, the Colenco Power Engineering, will not be ordered to supply the Generator Fire Protection System (GFPS). Generally, GFPS is a substantial part in the Specification and Delivery of the Generator.”*

-The English Consultant coded EMP035, explained that: *“Our recommendations on generator fire protection would be based on our own experience and the client/end users’ previous experience.”*

-The Swedish Consultant coded EMP041, explained that: *“We do not supply GFP’s. Generally the GFP’s purchaser decides if a generator has to be equipped with GFP.”*

**G 6.3 -**

6.3) If the choice is yours do you have a preferred extinguishing method?

- Yes

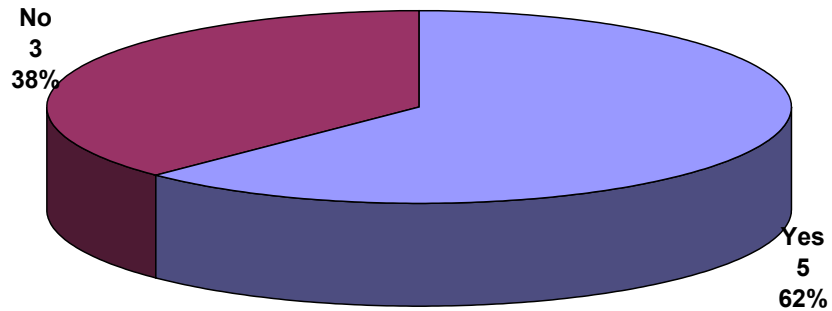
- No

If yes please indicate which:

If no, please indicate how you determine the extinguishing media for each particular case:

The check-box question analysis resulted in the following graphic:

**6.3 - If the choice is yours do you have a preferred extinguishing method?**



The majority of Consulting have a preferred extinguishing method, and this will be explored in the open question part, that is divided in two.

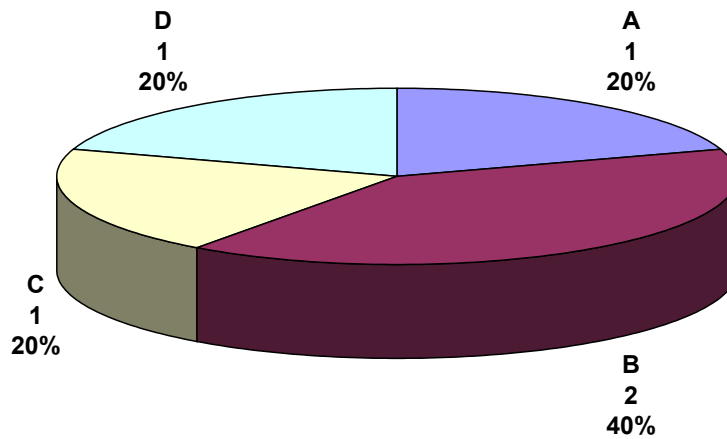
Open question 1 analysis results (If yes please indicate which):

The answers received allowed to categorize and the result is the following:

G 6.3 - If the choice is yours do you have a preferred extinguishing method? If yes please indicate which:		
Categories	Legend	Quantity
A	Inert gas (like Inergen)	1
B	Water	2
C	CO2 or Inergen	1
D	Type according to Standards	1
E	Blank	4
<b>Total of answered questions</b>		<b>9</b>

The following graphic shows the result (the four blank answers were not considered):

**6.3 - If the choice is yours do you have a preferred extinguishing method?  
If yes please indicate which:**



Open question 2 analysis results (If no, please indicate how you determine the extinguishing media for each particular case): we got three answers whereas two from Sweden have the same text:

G 6.3 - If the choice is yours do you have a preferred extinguishing method? If no, please indicate how you determine the extinguishing media for each particular case:	
EMP035 (United Kingdom)	Most of the recent projects have been CO2 generator fire protection. CO2 was generally chosen because of previous client experience.
EMP059 (Sweden)	With modern generators / windings that don't maintain fire, we usually don't install extinguishing facilities.
EMP041 (Sweden)	With modern generators / windings that don't maintain fire, we usually don't install extinguishing facilities.

Considering only the different answers we see a tie between CO<sub>2</sub> and Water.

**G 6.3.1 –**

6.3.1) – If you have the choice, which is the extinguishing media you usually chose for:

a) Above water power plants (open-air):

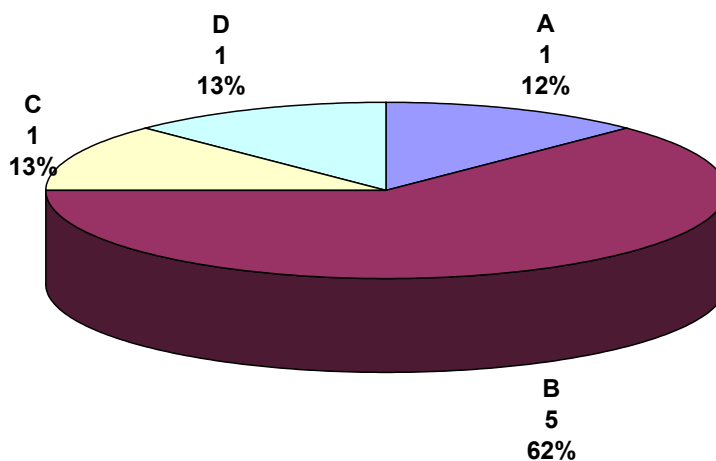
b) Cavern type power plants:

This pure open question is composed by two alternatives considering the local of installation of the power plant:

Open question 1 analysis - Above water power plants (open-air): the result of the categorized study can be seen on the graphic below (complete details on the corresponding annex):

6.3.1 - If you have the choice, which is the extinguishing media you usually chose for: above water power plants (open-air):			
Categories	Legend		Quantity
A	Water, CO2 or inert gas		1
B	Water		5
C	CO2		1
D	None		1
E	Blank		1
<b>Total of answered questions</b>			<b>9</b>

**6.3.1 - If you have the choice, which is the extinguishing media you usually chose for: above water power plants (open-air):**

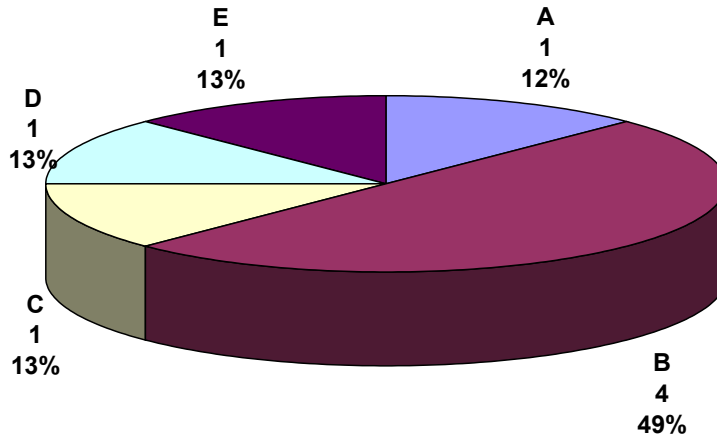


Open question 2 analysis - Cavern type power plants; the categorized study resulted as follows:

6.3.1 - If you have the choice, which is the extinguishing media you usually chose for: Cavern type power plants:		
Categories	Legend	Quantity
A	Water, CO2 or Inergen	1
B	Water	4
C	Inert gas	1
D	CO2	1
E	None	1
F	Blank	1
<b>Total of answered questions</b>		<b>9</b>

The following graphic gives a visual display of the result:

**6.3.1 - If you have the choice, which is the extinguishing media you usually chose for: Cavern type power plants:**



Conclusion of this item: in either one of the alternatives the preference was Water.

**G 6.4 -**

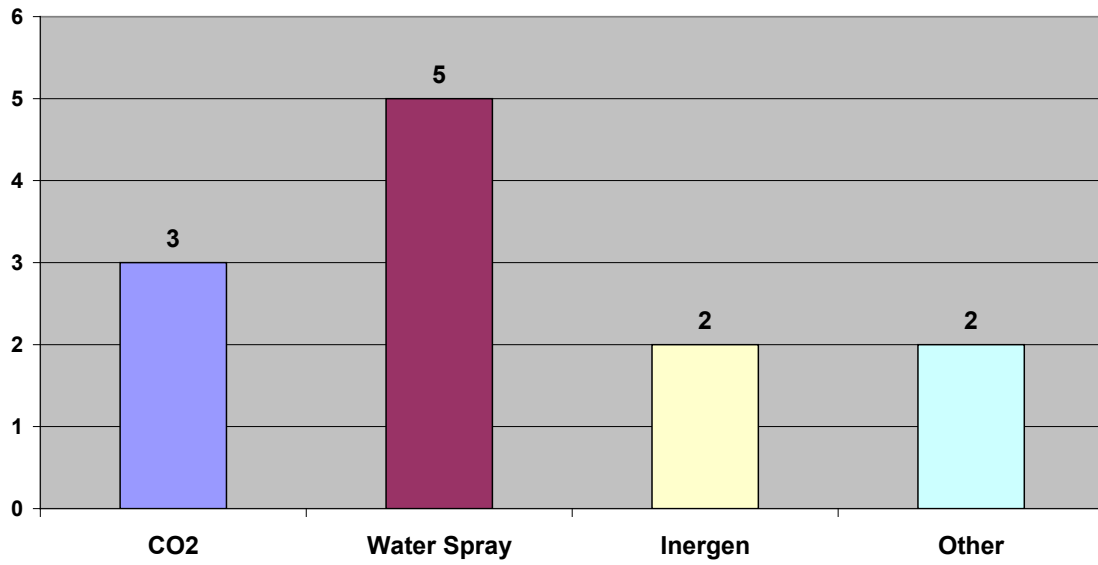
6.4) From your experience, which is the type of generator fire extinguishing method more frequently used nowadays?

- CO<sub>2</sub>
- Water Spray
- Inergen
- Other

If other please specify:

The check-box part of his question can be analyzed with the following graphic:

**6.4) From your experience, which is the type of generator fire extinguishing method more frequently used nowadays?**



This result shows two extinguishing medias that are gaining importance which are Water and Inergen. Three Consulting checked two alternatives each, therefore the total number of 12 alternatives checked in this case.

Open question analysis (If other please specify), the answers can be seen below:

EMP042 (Norway)	For new installation, None
EMP049 (Sweden)	CO2 only on old generators

**G 6.4.1 -**

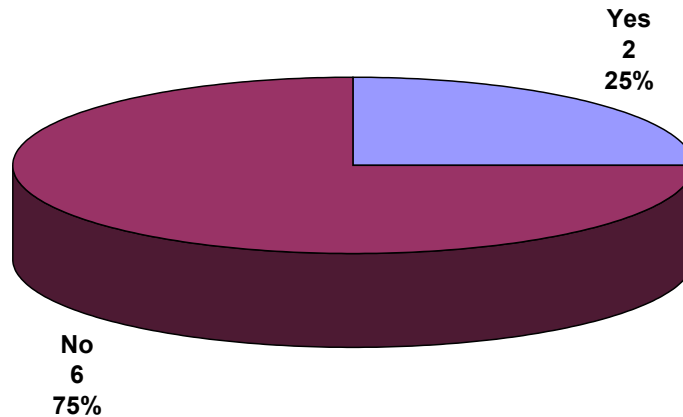
6.4.1) Do you recognize any change towards the former trend (status quo) in fire protection systems your country?

- Yes  - No

If yes, please state it here:

The check box part of this question resulted in the following graphic:

**6.4.1 - Do you recognize any change towards the former trend (status quo) in fire protection systems your country?**



This result shows that from the Consulting point of view there is no change in the former trend on GFP in the corresponding countries. There was one blank answer not considered in the graphic above.

Open question analysis (If yes, please state it here); since there were two answers “Yes” here we present the corresponding statements:

-The Swiss Consultant coded EMP011, explained that: “*There are more and more inert gas fire protection systems.*” In fact this survey shows the advance of Inergen as extinguishing media in Waterpower applications.

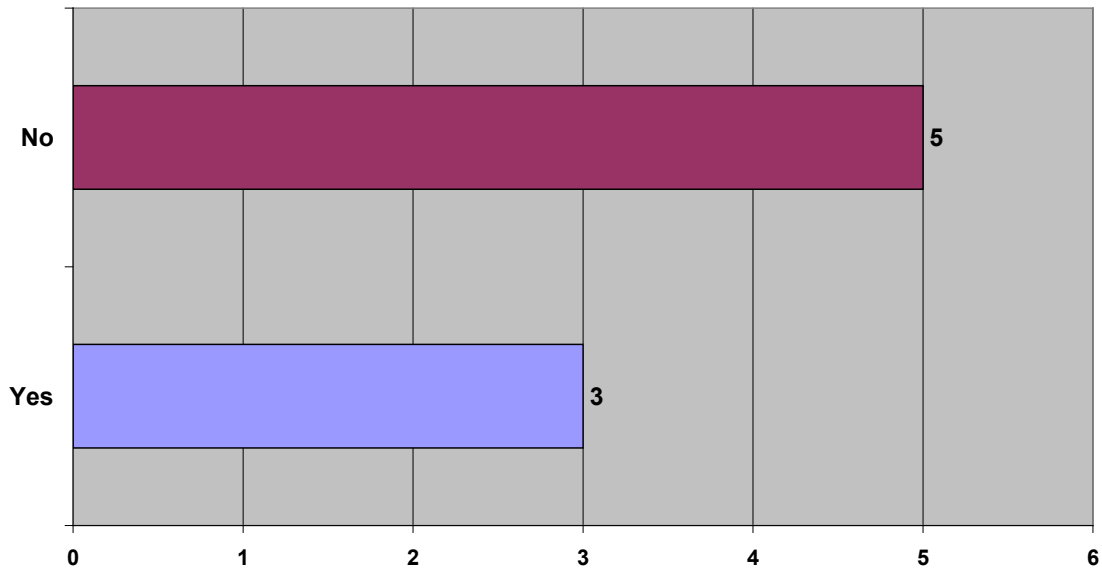
-The Chinese Consultant coded EMP021, explained that: “*We considering and investigating the application scope of the fire protection system for generator in our country.*” The result of this investigation will be very interesting, considering the importance of the Chinese waterpower sector.

**G 6.5 -**

6.5) Are there standards recommending generator fire protection in your country?  
 - Yes  - No

This is a pure check-box question that resulted in the following graphic:

**6.5 - Are there standards recommending generator fire protection in your country?**



This question was explored deeper in the following two open questions. There was one blank answer not considered in the graphic above.

**G 6.5.1 -**

6.5.1) If yes, which standards are these?

In this pure open question we got the following contributions:

- The Chinese Consultant coded EMP021, explained that they have: “*GB50219 for water and GB50193 for CO2 gas.*” In China there are country own Standards.
- The English Consultant coded EMP035, explained that they have: “**NFPA**” But this cannot be accepted in this case because the question pursues to find out where do countries own Standards exist.
- The Swedish Consultant coded EMP041, explained that: “*SS-EN*” In Sweden there are country own Standards too.

**G 6.5.2 -**

6.5.2) If not which standards do you follow in your work?

In this pure open question we got the following contributions:

- The Swiss Consultant coded EMP011, explained that they use the: “*General standard for fire protection in buildings called ‘Brandschutzvorschriften’*” (that stands for Fire Protection Norms).
- The English Consultant coded EMP014, explained that they use the: “*NFPA 851*”

-The German Consultant coded EMP030, explained that they use the: “*NPFA, IEC, VDE, DIN*”.

-The Swedish Consultant coded EMP049, explained that they use the: “*Provisions and recommendations issued by the National Board of Housing, Building and Planning.*”.

**G 6.5.2.1 -**

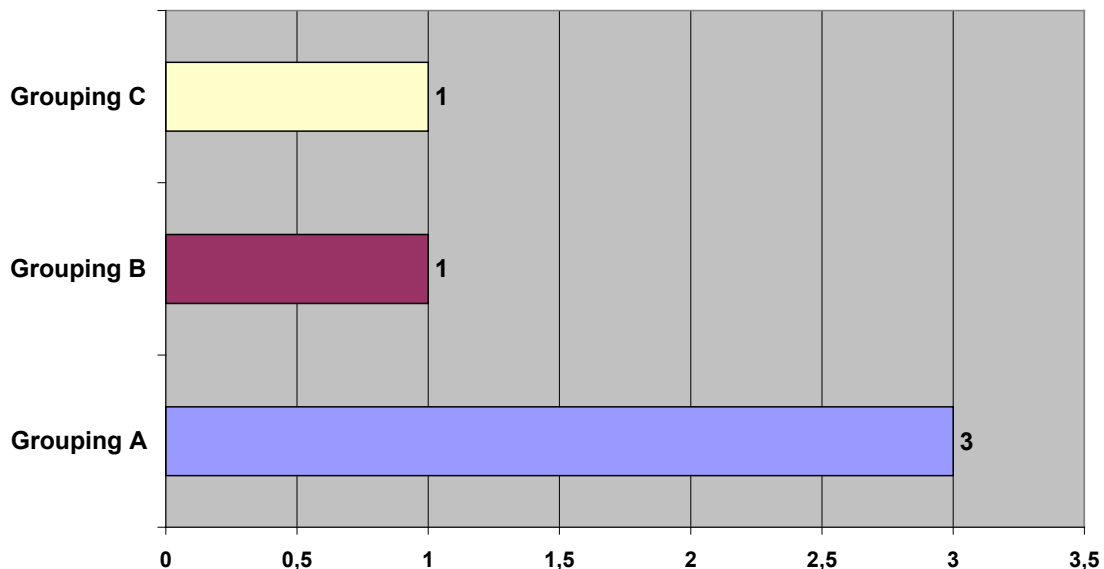
6.5.2.1) Are there critical items in the application of these Standards that require special attention?

This pure open question was categorized according to the following table:

6.5.2.1) Are there critical items in the application of these Standards that require special attention?		
Categories	Legend	Quantity
Grouping A	No critical items	3
Grouping B	Bearings inside generator enclosure	1
Grouping C	Local insurance practice and regulations	1
Grouping D	Blank	4
<b>Total of answered questions</b>		<b>9</b>

We got the following graphic:

**6.5.2.1 - Are there critical items in the application of these Standards that require special attention?**



In this case the “No concern” group had 3 votes which is the majority. There were four blank answers that were not considered in the graphic above. The two concerns we had are the following:

EMP014 (United Kingdom)	Bearings inside the generator enclosure.
EMP041 (Sweden)	Local insurance practice and regulations

**G 6.5.3 -**

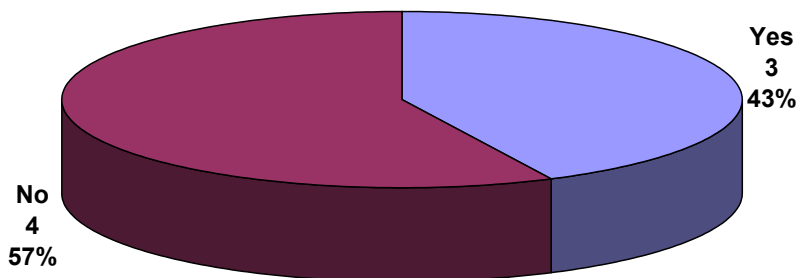
6.5.3) Considering the existence of the recently launched standards (for instance NFPA 851), is there a need of any additional specific international standard on generator fire protection?

- Yes  - No

Any additional comment? Please state here:

The result of the check-box part of this question can be seen in the graphic below:

**6.5.3 - Is there a need of any additional specific international standard on generator fire protection?**



Open question analysis (Any additional comment? Please state here); we reproduce the received statement as follows:

-The Chinese Consultant coded EMP021, explained that: *“Based on the actual situation and practice, much many customers and manufacturers put forward the necessity of installation of fire extinguishing equipment, so we propose to make a report regarding the availability and scope applied for fire protection in power plant.”*

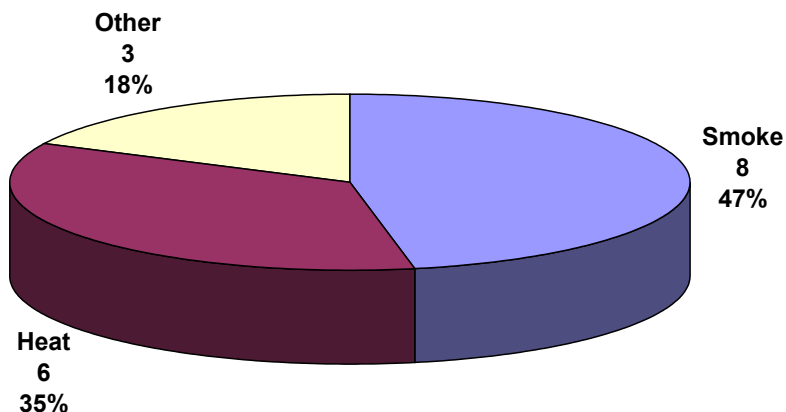
**G 6.5.4 -**

6.5.4) What is the state of the art in the detection in accordance to your experience?

- Smoke
- Heat
- Flame
- Other – please describe:

Some Consulting did check more than one alternative, resulting in 17 marked items, and the corresponding graphic is the following:

**6.5.4 - What is the state of the art in the detection in accordance to your experience?**



Open question analysis (Other – please describe) in this case we got the same statement of the Swedish Consulting coded EMP0 and EMP0 as follows: “*Aspirating smoke detection system*”. This is a new application of WESDA (or similar) systems to hydrogenerators. The results are showing to be very good, this may be a new tendency.

**G 6.5.4.1 -**

6.5.4.1) Which are the types of detection devices you normally use and/or recommend?

This is a pure open question and the answers are as follows:

Company	Result
	Answer
EMP011 (Switzerland)	We require the application, however, neither recommend nor favorize certain types of detection devices.
EMP021 (China)	Normally we use smoke detector with ionization type and heat detector with temperature fixation type.
EMP042 (Norway)	Smoke/heat
EMP049 (Sweden)	Smoke detectors

The answer of the Swiss Consultant shows a typical Consulting statement, because it shows a neutral position.

#### G 6.5.4.2 -

6.5.4.2) Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation (here is meant the unwanted release of the extinguishing media)?
---

This is a pure open question and the answers are as follows:

Company	Result
	Answer
EMP011 (Switzerland)	We require the application, however, neither recommend nor favorize certain types of detection devices.
EMP014 (United Kingdom)	Heat
EMP021 (China)	We have a closed relationship with the manufacturers, research centers and the design institute. As a result, an agreement is reached to minimize unwanted fire extinguishing system operation as stated in clause 1.11 The fire extinguishing system will be released in case of: a) Some of settling smoke detectors actuated; b)Some of settling heat detectors actuated; c) Differential and or neutral protection already tripped off; d) Circuit breaker of high voltage side of main transformer and de-escalation breaker already tripped off..
EMP042 (Norway)	None

The comment from the Chinese Consulting refers to the comment given in the item 1.11 of the Group 1 Users How do you prevent unwanted (unnecessary-accidental) release of generator fire extinguishing system?, which was: *“The fire extinguishing system will be released in case of: a)Some of settling smoke detectors actuated; b)Some of settling heat detectors actuated; c)Differential and or neutral protection already tripped off; d)Circuit braeker of high votage side of main transformer and deescalation breaker already tripped off.”*

**G 6.6 -**

6.6) Do you usually cooperate with the generator manufacturer on the Generating Fire Protection Question?

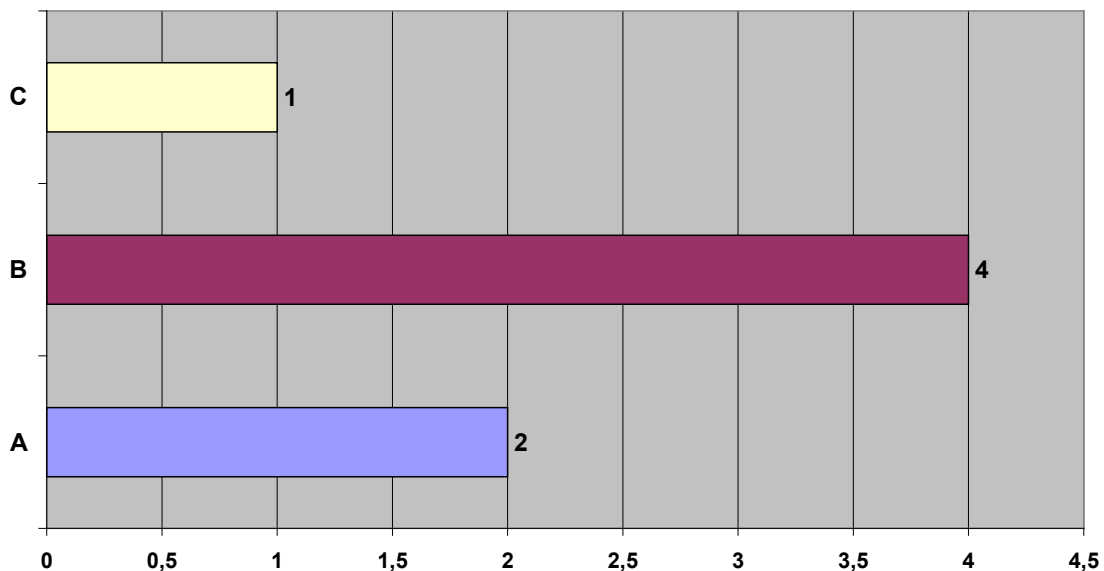
- Yes, there is a cooperation and joint work
- No, our work ends with the issue of the specifications
- It depends from case to case, please specify:

The check-box part of this combined question offered 3 alternatives, as follows, a categorization was made in order to allow a graph to be made (long alternative names):

Category	Description
A	Yes, there is a cooperation and joint work
B	No, our work ends with the issue of the specifications
C	It depends from case to case, please specify

The statistics showed the following graph:

**6.6 - Do you usually cooperate with the generator manufacturer on the Generating Fire Protection Question?**



There were two blank answers that were not considered in the graphic above.

Open question analysis (It depends from case to case, please specify) this alternative showed the following result:

EMP035 (United Kingdom)	In our performance specifications the fire protection system is usually included within the generator specification.
-------------------------	--

**G 6.7 -**

<p>6.7) Do you usually cooperate with fire protection equipment manufacturer on the Generating Fire Protection Question?</p> <p><input type="checkbox"/> - Yes, there is a cooperation and joint work</p> <p><input type="checkbox"/> - No, our work ends with the issue of the specifications</p> <p><input type="checkbox"/> - It depends from case to case, please specify:</p>
--

The check-box part of this combined question offered 3 alternatives, as follows, a categorization was made in order to allow a graph to be made (long alternative names):

<b>Category</b>	<b>Description</b>
A	Yes, there is a cooperation and joint work
B	No, our work ends with the issue of the specifications
C	It depends from case to case, please specify

The statistics showed the following table:

<b>Result</b>		
<b>Answer</b>	<b>Category</b>	<b>Quantity</b>
Yes, there is a cooperation and joint work	A	4
No, our work ends with the issue of the specifications	B	4

There was one blank answer that was not considered in the statistics above. As we can see the type of work depends upon each particular Consulting Company.

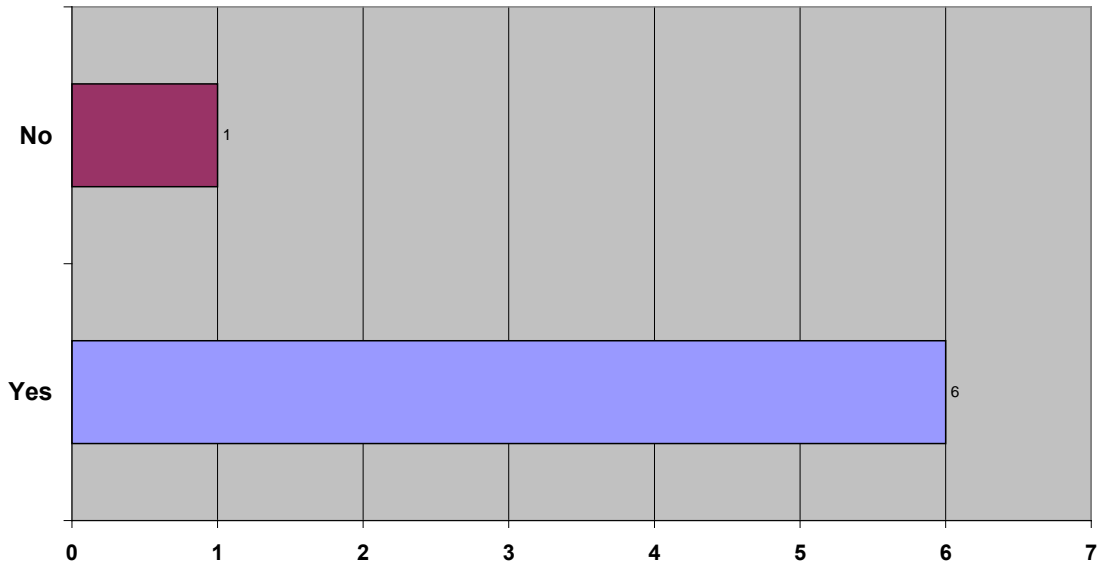
Open question analysis (It depends from case to case, please specify) no answer was given to this exploratory question.

**G 6.8 -**

<p>6.8) Do you work also on refurbishment of Fire Protection Equipment on hydro generating plants?</p> <p><input type="checkbox"/> - Yes</p> <p><input type="checkbox"/> - No</p> <p>Do you have any comment on this issue you would share with us?</p>
---

The Check-box part of this question resulted in the following graphic:

**6.8 - Do you work also on refurbishment of Fire Protection Equipment on hydro generating plants?**



There were two blank answers that were not considered in the graphic above.

Open question analysis (Do you have any comment on this issue you would share with us?) no answer was given to this exploratory question.

**G 6.9 -**

6.9) Do you follow you projects during erection and commissioning phrases?  
 - Yes  
 - No  
 If yes, can you tell us what are the most frequent problems you had to face in the case of the Fire Protection Equipment?

In the check-box part of this question the answer “Yes” was unanimous.

Open question analysis (If yes, can you tell us what are the most frequent problems you had to face in the case of the Fire Protection Equipment?) in this case we got the following answers:

Company	Result
	Answer
EMP021 (China)	The performance of test at site for fire protection equipment.
EMP042 (Norway)	None

The observation made by the Chinese Consultant is very actual, because the testing of the GFP and the adjusting of the smoke and temperature sensors is a very complicated task,

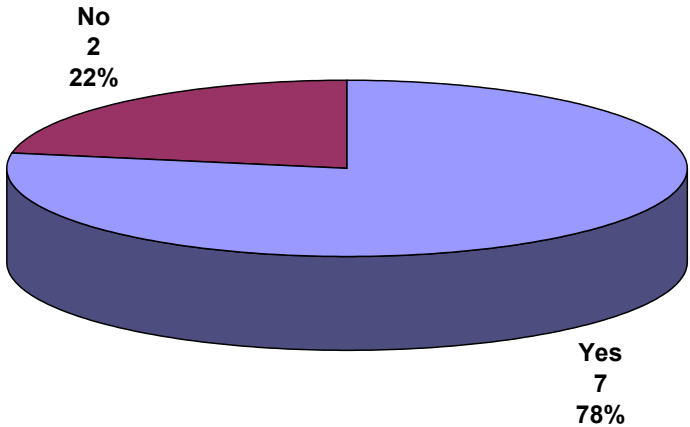
The testing of a extinguishing media deployment is very often bound with costs and additional work (dry out of the unit should the media be water).

**G 6.10 -**

6.10) In your opinion is a Generator Fire Protection installation required nowadays?  
 - Yes  
 - No  
 Do you have any comment on this issue you would share with us?

The answers to this very important check-box question resulted in the graphic below:

**6.10 - In your opinion is a Generator Fire Protection installation required nowadays?**



The majority of the participant Consulting Companies agrees to the importance of the use of GFP nowadays.

Open question analysis (Do you have any comment on this issue you would share with us?); the additional explanations received are the following:

Company	Result
	Answer
EMP021 (China)	"yes" is for the big and huge machines, and "no" is for small and medium size machines.
EMP049 (Sweden)	Only fire detectors on modern epoxy type generators. Older Bitumen type generators still need fire extinguishing system

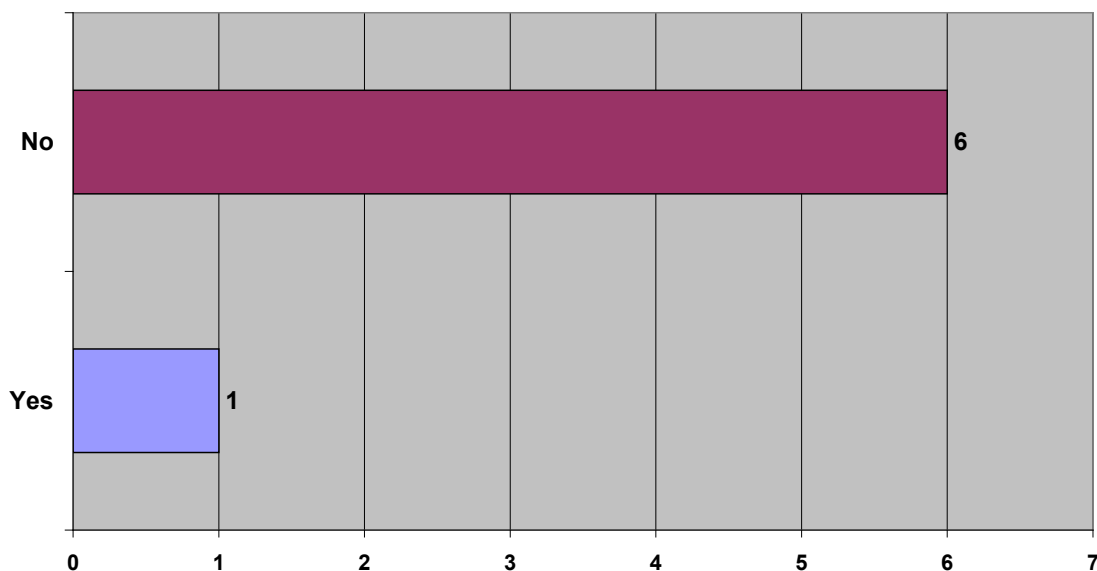
This question is part of the questions that allow a comparison between Users, Manufacturers and Consultants.

**G 6.11 -**

6.11) According to your opinion, is there any question that is missing in this part of the questionnaire?  
 - Yes  - No  
If yes, please state it here:

The check-box part of this question resulted in the following graphic:

**6.11 - According to your opinion, is there any question that is missing in this part of the questionnaire?**



It is important to point out that one Consulting informed that there is something to be surveyed the next time. The question got two blank answers that were not considered in the graphic above.

Open question analysis (If yes, please state it here) and the suggestion to be pursued further on is the following: But unfortunately none of the Swedish Consulting Company, coded EMP049, that answered “Yes” in the check-box part of this question, did not expressed its concern about a missing item on the questionnaire.

## H – FINAL CONCLUSIONS:

### Introduction:

Starting the conclusions of this work that took Five years to be completed it is time to thank again to all who participated by giving their answers to allow this work to be done. The great number of contributions was the most important characteristic of this UPDATE. The complete material received was included in this work in the form of statistical tables that do compose the annexes of each module.

The UPDATE took the original questionnaire made in 1981 by the group led by Dr. Rolf Dieter Kranz and expanded it following to several comments received during the first stage of the work in which the six questionnaires were defined.

There is an important difference between the original work and the present UPDATE. In the original work there was no separation between Users and Manufacturers, this did not allow a discrete analysis of the answers. In the present UPDATE a separation was made and categories for Insurance Companies, Refurbishment Companies, Research Institutes and Consulting Companies were established:

Original Groups of the present UPDATE and the number of received answers:		
1	Generator user (owner)	35 answers
2	Generator Manufacturer	10 answers
3	Insurance Company, Reinsurance Company or Insurance Broker	05 answers
4	Erection, Commissioning, Refurbishment, Maintenance.	(4 answers)
5	Research Centers and Universities	(2 answers)
6	Consulting Companies	09 answers
Total of		<b>65</b> answers

In fact the contents of the answers received for Refurbishment Companies (Group 4) and Research Institutes (Group 5) did not allow them to be considered.

The Group 1 – Users was the biggest one and the individual report presented in the 2009 Sidney meeting has 174 pages. Much important information was received and we point out the examples of fire accidents, some of them with important data that can serve as guideline and research material.

The Group 2 – Manufacturers provided information based upon the manufacturers practice, and attention was given to the question of flammability grade of insulation material – a point to be surveyed further on.

The Group 3 – Insurers, although present in this work with five contributions, brought important information on specifics of how Insurance Companies deal with their customers. The data given for some fire accident is very important moreover due to the special insurer's point of view, it is a very valuable source of information.

The Group 6 - Consulting again showed a peculiar point of view that allows understanding how decisions are met by those that use to make the power plant's overall design.

### H1 – Considerations on the size of this work:

This UPDATE did reach a huge dimension and allows to interested parties to survey many aspects of the Generator Fire Protection application, and this from different points of view. All answers received are part of this work and form the extensive annexes of each module.

Not considering the analysis needed for the conclusions and the analysis of Dr. Kranz's work we have the following situation counting the surveyed items (check-box and open type questions):

Statistics of the total surveyed items:		
Part 1	Comparison between similar questions from the Groups 1, 2 and 6	465
Part 2	Isolated analysis Group-01 – Users	3640
Part 3	Isolated analysis Group-02 – Manufacturers	440
Part 4	Isolated analysis Group-03 – Insurance Companies	145
Part 5	Isolated analysis Group-06 – Consulting Companies	324
	Total of surveyed items: Check-Box or Open questions	<b>5014</b>

## **H2 – Conclusions of the present Generator Fire Protection UPDATE – questionnaires comparison:**

Due to the size of this survey the conclusions will be concentrated on the comparison between the former work and the present one. But there is a great amount of additional data that may be accessed for specific surveys in the corresponding section of this UPDATE.

### **H 2/1 – Are there (GFP) Standards in your country?**

This aspect was addressed by following questions;

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	1	2	14	Focus on international
UPDATE Groups				
Group 1 – Users	D 1.1	10	24	Focus on country own Stand.
Group 2 – Manufacturers				
Group 3 – Insurers				
Group 6 – Consulting	G 6.5	3	5	Focus on country own Stand.

As a conclusion the situation reported by Dr. Kranz on the International level remains valid; and the survey made by the UPDATE researching the availability of national standards showed that with the exceptions listed below, there are no specific national standards according to information from the Group 1 - Users and Group 6 - Consulting: Canada, China, England, Macedonia, Mexico, Poland, Russia, Switzerland, Sweden, USA. In some cases the NFPA was indicated as national standard by countries other than the USA; this fact shows the importance and broad application of this standard world wide – we can say that the NFPA with minor adaptations could be considered as international standard for GFP.

### **H 2/1.1 – Which standards are these?**

As already said on the international level there is absence of International Standards – but the NFPA Standards were indicated very often. On Dr. Kranz's questionnaire the question 1.1 deals with this subject.

On the national level some of the participating Countries indicated national standards and this can be checked on the questions: Group 1: D 1.1.1 and Group 6: G 6.5.1.

## H2/2 – Do you recommend or install Fire Protection Equipment?

This aspect was addressed by following questions:

	Involved question	Y	N	Remarks
Dr. Kranz Questionnaire	2	16	8	
UPDATE Groups				
Group 1 – Users	D 1.2	23	9	
Group 2 – Manufacturers	E 2.1	4	6	Opposite to the others
Group 3 – Insurers				
Group 6 – Consulting	G 6.10	7	2	

Considering the check-box questions analysis the installation of GFP was recommended on Dr. Kranz's work and is recommended on the present survey by a significant number of participants.

### H2/2.1 – What are the reasons (for recommending GFP)?

This aspect was addressed by following questions:

	Involved question	Remarks
Dr. Kranz Questionnaire	2.1	
UPDATE Groups		
Group 1 – Users	D 1.2.1	
Group 2 - Manufacturers	(E 2.1.1)	Indirect question
Group 3 – Insurers		
Group 6 – Consulting	G 6.10	

**NOTE:** Dr. Kranz indicated the comments to the questions by means of index numbers and a list of comments. In order to allow the statistical survey of these valuable information tables were made in a similar way as those made for the UPDATE. The original Dr. Kranz document we received as basis for the UPDATE are available in the corresponding annex, as well as the processed tables.

For this open question the result got by Dr. Kranz can be represented by the following table:

<b>2.1 What are the reasons (for recommending GFP)?</b>		
Grouping A	Satisfactory experience, oil dust, unmanned stations	5
Grouping B	Required by National Standards GOST 5615-80 (USSR)	1
<b>Total of answered questions</b>		<b>6</b>

Five from the six received contributions recall for satisfactory experience with GFP as the reason for recommend its use.

On the UPDATE the question of reasons for use of GFP was explored by open question stated immediately after the Check-Box questions "Yes" or "Not" for the GFP use. The complete answers received can be followed at the question "1.2.1 – What are the reasons for that?" at the Group 1 Users; and question "2.1.1 – If yes, which type" at the Group 2 Manufacturers.

In brief we can say that:

For the Group 1 - Users: This open question got many more answers in the UPDATE, and the categorized study showed that 19 answers point in to the direction of recommending the use of GFP (the categories recalled for: safety and safety reasons, protection and reduce or minimize damages). On the other hand the categories “do not install” and “in process of removing GFP” got a total of 9 answers and shows a trend on the direction of not using GFP; the question still to be answered recalls for the consistency of this trend.

The Group 2 - Manufacturers in general are strongly relying on the non flammability characteristics of the insulation material used nowadays, but this assumption is not confirmed by the corresponding Standards nor clear evidences were shown to back up this kind of position; that is still lacking of a concrete validation; it is not questionable that the new type of insulation shows significative advance towards the elder types, but the flammability question is still an open issue. There are experts that say that the “modern” materials are no less inclined to support combustion than previous materials – albeit at higher ignition temperatures.

Among the answers received to the question “from the generator manufacturer's standpoint, do you recommend the use of Generator Fire Protection” one, given by a Swiss Manufacturer called our attention “*If acceptable by client we recommend Inergen (Switzerland). For Asia Water spray is preferred then CO2*” that shows the tendency of the use of Inergen (more modern and safer for the operators) in Europe and less restrictive conditions in other parts of the world.

The Group 6 – Consulting: answers did not allow exploring further aspects on this subject.

### H2/ 3 - Has there been a different opinion in the past?

This question was stated to find out if there is any difference between the present and past fire protection strategies on generators and this subject was addressed by following questions:

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	3	7	7	Tie situation
UPDATE Groups				
Group 1 – Users	D 1.3	18	17	Almost tie situation
Group 2 – Manufacturers	E 2.2.1	1	8	
Group 3 – Insurers				
Group 6 – Consulting	G 6.4.1	2	6	

The check-box question showed that the result of Dr. Kranz's work (tie 7 Yes to 7 No) applied to a similar situation the UPDATE has shown for the Group 1 – Users. On the other hand the Group 2 – Manufacturers and Group 6 – Consulting showed that their perception is that there is no difference between past and present situation which, considering a lump sum, is the overall tendency.

### H2/ 3.1 - What are the reasons of the change in opinion?

In the UPDATE this question was stated to find out the reasons for the change should the organization have changed the protection strategy:

	Involved question	Remarks
Dr. Kranz Questionnaire	3.1	
UPDATE Groups		
Group 1 – Users	D 1.3	open question
Group 2 – Manufacturers		
Group 3 – Insurers		
Group 6 – Consulting		

Dr. Kranz's work open question answers can be resumed in the following table:

<b>3.1 What are the reasons for change in the opinion?</b>		
Grouping A	Pollution by oil dust	1
Grouping B	With sufficient heat and oxygen also modern insulation is flammable	4
Grouping C	Use of modern self extinguishable insulation	5
<b>Total of answered questions</b>		<b>10</b>

Here an interesting aspect, at the time of Dr. Kranz's work companies were convinced that: "with sufficient heat and oxygen also modern insulation is flammable" this affirmation was recalled in the present UPDATE. But the opinion "use of modern self extinguishable insulation" was present; each one pointing to the opposite direction.

On the UPDATE the Group 1 – Users survey the corresponding open question "If your organization changed the protection strategy, what are the reasons for the change?" gave 32 answers that were categorized as follows:

Remove GFP with use of new insulation material

Implement water

To prevent unnecessary releases

To improve availability and effectiveness

Improvement in detection

Removing CO<sub>2</sub>

Changes depend upon insulation type

Focus on man security and environment

Changes will depend on GFP behavior

No clear tendency was obtained in this case, but the item D 1.3.1 of the Group – 1 analysis allows exploiting this question in details. But, in order to give an example of how rich the received comments can be we reproduce herewith the comment given to the Grouping F [Improvement in detection] by a Brazilian User telling the following: "Our company's fire detection system is composed of thermal and smoke detectors. CO<sub>2</sub> is discharged whenever a thermal detector and a smoke detector operate. A first change was introduced in order to allow the fire protection system operation in the event of severe faults which could cause the opening of the generator doors and hatches. In 1992, due to an explosion caused by a stator fault, the generator doors opened and their micro switches blocked the fire protection system operation. In order to allow the future operation of the fire protection system in the case of severe faults, the phase differential (87G) and turn-to-turn (87SP) protections were connected in parallel with the micro switches. A second change was introduced due to an improper operation of one generator fire protection system in 2007. The release of CO<sub>2</sub> and the generator trip were caused by a thermal and a smoke detector incorrect operation. In order to prevent this kind of incorrect behavior, the fire protection system control panel output was connected in series with protections 87G and 87SP." This

important comment showed how the happenings during the operation, and the consequent accidents provoked change in the opinion of this particular User.

Additionally to this open question the present UPDATE opened the focus of this question and surveyed the following topics for the Group 1 – Users (most of this additional survey was suggested by Users during the elaboration of the questionnaire) starting with the question “D 1.3.1 - If your organization changed the protection strategy, what are the reasons for the change?”; followed by 12 additional exploratory questions. The corresponding answers and statistical analysis can be seen on the upgrade’s part D.

#### H2/ 4 - **What system and ext. media have been installed recently?**

This question allows a tendency comparison, starting from the table below that summarizes the results from Dr. Kranz’s study compared with the UPDATE’s results:

	Dr. Kranz's Questionnaire	UPDATE Groups				UPDATE Totals
		Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 – Consulting	
Involved question	4	D 1.6.2	E 2.2		G 6.4	
Alternatives:						
CO <sub>2</sub>	8	101			3	104
H <sub>2</sub> O		91			5	96
CO <sub>2</sub> +H <sub>2</sub> O	4					
CO <sub>2</sub> - inland and H <sub>2</sub> O - abroad	2					
Inergen		51			2	53
No GFP installed		242				242

Although there are other extinguishing media being used in generators, as dry chemical powder used in Japan, this particular question indicated the alternatives above. On the original UPDATE’s questionnaire the alternative “no GFP installed” was not present, but this alternative represents one trend (the 242 units running without GFP indicated above belong to only one Austrian user). The other new aspect, in respect to Dr. Kranz’s work, that came in to consideration was the use of inert gas, for instance Inergen, as extinguishing media.

In reports of the questions indicated in the table above detailed data is available.

#### H2/ 5 – **(In your opinion which is the) Efficient media?**

In Dr. Kranz’s work three alternatives were considered. In the UPDATE this question was stated to the Group 1 – Users as an open question allowing the free indication of the Users opinion:

		UPDATE Groups				
	Dr. Kranz's Questionnaire	Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	5	D 1.7				UPDATE Totals
Alternatives:						
CO <sub>2</sub>	6	12				12
H <sub>2</sub> O	1	7				7
CO <sub>2</sub> +H <sub>2</sub> O	3					
Inergen		3				3
Avoid fire begin (prevention)		1				1
Depends on type of application		1				1
Fire Extinguisher		1				1
Foam extinguisher		1				1
No experience or no opinion		3				3

As well as on Dr. Kranz's work as in the UPDATE CO<sub>2</sub> was considered to be the most efficient extinguishing media. In fact CO<sub>2</sub> is the most used extinguishing media and this fact offers more experience with this particular extinguishing method.

## H2/ 5.1 – (In your opinion which is the) Media harmful to machine?

Again Dr. Kranz's work limited the alternatives to three. This question was stated to the Group 1 – Users again as an open question.

		UPDATE Groups				
	Dr. Kranz's Questionnaire	Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	5.1	D 1.7.1				UPDATE Totals
Alternatives:						
CO <sub>2</sub>		1				1
H <sub>2</sub> O	4	16				16
CO <sub>2</sub> +H <sub>2</sub> O						
Gas or Halon		2				2
Gas – Water		1				1
Chemical Dust		1				1

Not defined or None		3				3
No experience or no opinion		1				1

On the former work as well as on the present one, water is considered to be most harmful extinguishing media to the machine. This is an interesting result considering the fact that many companies nowadays use water and others declared to be switching to water; one may wonder if they are aware of the real situation of the generators after the use of water to suppress a fire. In the UPDATE we got statements of problems with rusted stator core laminations after water deployment, even in those allegedly treated with special protective enamel.

## H2/ 5.2 – (In your opinion which is the) Media dangerous to human health?

Dr. Kranz's work did not get any answer to this question, it may be understood that the participants did not recognize any media as being harmful to humans. On the UPDATE this aspect was stated as an open question:

		UPDATE Groups				
	Dr. Kranz's Questionnaire	Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	5.2	D 1.7.2				UPDATE Totals
Alternatives:						
CO <sub>2</sub>		28				28
H <sub>2</sub> O						
Halon		4				4
N <sub>2</sub>		3				3
Foam		1				1
Any Gas		1				1
Chemical powder		1				1
Nothing		1				1

CO<sub>2</sub> was indicated by the Users as being the most harmful media for humans. And this makes sense due to the CO<sub>2</sub>'s asphyxiating characteristics – it is clear that safety precautions shall be undertaken when this extinguishing media is used. On the other hand a well designed, installed and maintained CO<sub>2</sub> GFP equipment shall work safe and be very effective. To condemn a certain system due to a bad design, inadequate equipment or lack of maintenance and personal training seems to be completely out of focus.

## H2/ 6 – Do you specify measures to prevent accidents to men?

This is a broad question nowadays with the increasingly strict safety standards applied in many countries. But as Dr. Kranz's work was made this regulations were being started. The involved questions are shown in the table below:

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	6	11	2	From 14 answers 1 blank
UPDATE Groups				
Group 1 – Users	1.8	28	5	From 35 answers 2 blank
Group 2 – Manufacturers				
Group 3 – Insurers				
Group 6 – Consulting				

The majority of the former and the present answers show that measures to prevent accidents to men are undertaken; but there were negative answers on Dr. Kranz's work as well as on the present UPDATE.

This question was complemented by additional explanations on Kr. Kranz's work and this resulted in the following table:

<b>6 Do you specify measures to prevent accidents to men? Additional comments:</b>		
Grouping A	Alarm and notes	1
Grouping B	Alarm and notes + Interlock for entry in CO <sub>2</sub> protected area	2
Grouping C	Interlock for entry in CO <sub>2</sub> protected area	3
Grouping D	Interlock for CO <sub>2</sub> , none for water spray	1
<b>Total of answered questions</b>		<b>7</b>

On the Dr. Kranz's work the focus was given to alarm and interlock to make the CO<sub>2</sub> area safe. On the UPDATE side an open question was made for those that gave a positive answer to the check-box question asking: "Do you specify measures to prevent accidents to personnel? If yes, please specify" and a rich content of answers was received and can be seen in the corresponding annexes (D 1.8). The categorized (resumed) study showed the following result:

<b>Grouping</b>	<b>Legend</b>	<b>Quantity</b>
Grouping A	People trained according to regulations, accident prevention policy	7
Grouping B	Audible warning for evacuation of the area	1
Grouping C	Automatic and manual (CO <sub>2</sub> ) interlocking, disconnect system before going in to room - for inspection or maintenance	7
Grouping D	CO <sub>2</sub> systems are not acceptable	1
Grouping E	Forbid to enter housing after CO <sub>2</sub> discharge	1
Grouping F	Fire alarm and emergency exit lightning	1
Grouping G	Fire Door	1
Grouping H	Isolation requirements and choice of media	1
Grouping I	Forbid access to CO <sub>2</sub> protected areas when system is activated	2
Grouping J	Eliminate CO <sub>2</sub> systems when relay system is sufficient	1
Grouping K	Implementation of fire compartments on power plants	1
Grouping L	Planning to remove CO <sub>2</sub>	1
Grouping M	Answer does not match the subject asked	1
Grouping N	Blank	9
<b>Total of answered questions</b>		<b>35</b>

In the UPDATE new aspects did come in to discussion, as training, generators' area entrance regulations, and elimination of CO<sub>2</sub> systems.

## H2/ 6.1 – (Do you specify measures to prevent) Damage to machine?

The corresponding questions are the following:

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	6.1	-	-	No answer received!
UPDATE Groups				
Group 1 – Users	D 1.8.1	22	11	From 35 answers 2 blank
Group 2 – Manufacturers				
Group 3 – Insurers				
Group 6 – Consulting				

Since no answer for this question was received by Dr, Kranz's work this particular analysis will be concentrated on the UPDATE results. 67% of the Users do specify measures to prevent damages to machine and the exploratory open question resulted in the following categorized answers:

<b>1.8.1) Do you specify measures to prevent damage to machine? If yes, please specify:</b>		
Grouping A	Automatic protection, relays, release start interlocks	7
Grouping B	Fire door	1
Grouping C	Use of special detection (VESDA)	1
Grouping D	Keep CO <sub>2</sub> sprays distant from machine components	2
Grouping E	Monitoring of machine values, temperatures, ozone levels, etc.	2
Grouping F	Following manuals	2
Grouping G	Safety prevention during maintenance	1
Grouping H	Access restriction	1
Grouping I	Inspection by external authorities	1
Grouping J	Use of non flammable material	1
Grouping K	Water extinction is not acceptable	1
Grouping L	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of additional information given</b>		<b>22</b>

The complete answers can be seen in the corresponding annexes and we point out the Grouping C that mentioned the use of VESDA special smoke detection system, here the complete comment: *"Installing VESDA detection systems and require both a VESDA level 4 activation plus a differential protection relay operation before water is actually discharged into the generator. There is a manual discharge capability, but it still requires the VESDA level four activation."*

The other interesting comment is shown on the Grouping K, which reports the opinion of a Japanese User that said: *"Water extinction is not acceptable."* On the other hand in other question this Japanese User informed the use of dry chemical powder as extinguishing media; which on its turn is not usual for big machines.

## H2/ 7 - Should fire extinguishing be released automatically?

The involved questions were the following:

	Involved question	Automatically	Manually	Automatic or Manual	Remarks
Dr. Kranz's Questionnaire	7, 7.1 and 7.2	-	3	16	Some multiple answers
UPDATE Groups					
Group 1 – Users	D 1.9	12	4	16	From 35 answers 3 blank
Group 2 – Manufacturers					
Group 3 – Insurers					
Group 6 – Consulting					

On Dr. Kranz's work answers the automatic release was not an option and in the UPDATE it appears with 38% of votes. But the clear winner now and then is the option with either automatic or manual release.

There was only one additional comment on Dr. Kranz's work regarding this question that called for: "*With water as extinguishing media, only manual release*" this comment was stated by a company from Canada.

On the UPDATE the open question "D 1.9 What is your opinion or preferred method, as to how the generator fire extinguishing system should be released?" brought interesting comments that allowed a categorized study shown below, the complete comments can be seen in the corresponding annex:

<b>1.9.1) What is your opinion or preferred method, as to how the generator fire extinguishing system should be released?</b>		
Grouping A	Automatic	12
Grouping B	Manual	2
Grouping C	Automatic or manual (some with semi-automatic alternative)	8
Grouping D	If any: Automatic, provided with GFP than automatic provided that is will be de-energized when personnel in in the power station	1
Grouping E	Automatic or manual but with VESDA (smoke detector) level 4 activation	1
Grouping F	Automatic or manual but with thermal sensors interlock	1
Grouping G	Must have activated detectors and split phase operation	1
Grouping H	Temperature and generator relay interlock for actuation	1
Grouping I	Too little experience	1
Grouping J	Answer does not match the subject asked (not considered for the graphic)	7
<b>Total of answered questions</b>		<b>35</b>

For this question we received many answers and the compilation of them by means of a categorized study forming categories to enable the issue of a graphic to extract a tendency among the Users was not a simple task due to the diversity of the answers (in fact this situation occurred in other questions also). But in general it is possible to say that the variations involving automatic in conjunction with a manual alternative, or at least manual trip possibility, were the most often indicated answers. And particular situation also were mentioned as "*automatic as station are not manned*" – here it is to mention that we saw Users the have unmanned plants and leave the GFP equipment on manual resulting in a big risk for the plant.

Here we have a typical “philosophy” question; each company developed their own GFP triggering strategy. Some Users do prefer a wide flexibility, as this Chinese User: “We prefer to operate the system with fully automatic, semi-automatic and in combination with manual method.”

## H2/ 8 - How is the fire detected by personnel only?

This question stated by Dr. Kranz was analyzed together with his question “By instruments and which ones?” On the UPDATE side the corresponding question from the Group 1 – Users was: “D 1.10 - How is the fire detected in your generators?” The Group 2 – Manufacturers corresponding question was: “E 2.4.1 - Which are the types of detection devices you normally use and/or recommend?” And the Group 6 – Consulting corresponding question was: “6.5.4 - What is the state of the art in the detection in accordance to your experience?” The résumé table of these questions is the following:

	Dr. Kranz's Questionnaire	UPDATE Groups				UPDATE Totals
		Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	8	D 1.10	E 2.4.1		G 6.5.4	
Alternatives:						
By personnel (manual)	2	12				12
Smoke detector		23			8	31
Heat detector	3	24			6	30
Smoke + Heat detectors	10		10			10
Generator relay + detector		19				19
Other		3			3	6

On Dr. Kranz’s work USSR informed to use detection by personnel only, in Australia both alternatives were present. On the UPDATE the alternative manual operation was present 12 times.

## H2/ 9 - Is the fire ext. released by an other device then heat or smoke detectors?

This question stated by Dr. Kranz that received 10 answers Yes and 6 No, together with its exploratory question “(if Yes) What device?”, were covered on the UPDATE side by the results of the question H2/ 8 above and showed that the use of generator protection relays together with thermal and or smoke sensors in the GFP’s detection and release schemes was already a common practice in that times as it is now.

## H2/ 10 - Do you specify procedure to prevent unnecessary release?

This item involves the following questions:

	Involved question	Remarks
Dr. Kranz's Questionnaire	10	With additional open question.
UPDATE Groups		
Group 1 – Users	D 1.11	With additional open question.
Group 2 – Manufacturers	E 2.42	
Group 3 – Insurers		
Group 6 – Consulting	G 6.5.4.2	

Dr. Kranz's work on this question starts with a check-box question that ended in a tie situation (7 Yes and 7 No). The following result was obtained on exploratory part the question "What procedure? (...do you specify to prevent unnecessary release of the GFP equipment)":

<b>10 - Additional explanations to the question: What procedure?</b>		
Grouping A	Interlocking with electrical protection relays	3
Grouping B	Interlocking with electrical protection relays + Differential relay and winding fault relay	1
Grouping C	Electric protection relays + Release after visual confirmation	1
<b>Total of answered questions</b>		<b>5</b>

On the UPDATE we got the following situation:

For the Group 1 – Users:

<b>D 1.11 - How do you prevent unwanted (unnecessary-accidental) release of generator fire extinguishing system?</b>		
Grouping A	Dual protection	9
Grouping B	No protection for unwanted trip	1
Grouping C	VESDA detection system	1
Grouping D	Include generator electrical protection (eg. Differential Relay)	5
Grouping E	Block CO <sub>2</sub> at inspection works	3
Grouping F	Mechanical stoppers	1
Grouping G	Manual activation	1
Grouping H	Voting system involving two out of smoke or heat detectors, or electrical protection	2
Grouping I	Check fire alarms in intervals	2
Grouping J	Trip occurs if any of the available detectors (heat or smoke) or electrical protection actuates	1
Grouping K	Did not answer (not considered for the graphic)	9

The complete answers can be seen on the corresponding annex.

For the Group 2 – Manufacturers:

<b>2.4.2) Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation?</b>		
Grouping A	Smoke and Thermal plus protection relay	4
Grouping B	Use different type of detectors	2
Grouping C	Nothing special	3
Grouping D	Depends on customer's decision	1
<b>Total of answered questions</b>		<b>10</b>

For the Group 6 – Consulting:

<b>G 6.5.4.2 - Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation (here is meant the unwanted release of the extinguishing media)?</b>	
<b>Company</b>	<b>Result</b>
EMP011 (Switzerland)	We require the application, however, neither recommend nor favorize certain types of detection devices.
EMP014 (United Kingdom)	Heat
EMP021 (China)	We have a closed relationship with the manufacturers, research centers and the design institute. As a result, an agreement is reached to minimize unwanted fire extinguishing system operation as stated in clause 1.11 [The fire extinguishing system will be released in case of: a) Some of settling smoke detectors actuated; b) Some of settling heat detectors actuated; c) Differential and or neutral protection already tripped off; d) Circuit breaker of high voltage side of main transformer and de-escalation breaker already tripped off.].
EMP042 (Norway)	None

The prevention of unwanted operation of GFP was present in Dr. Kranz's work and in the UPDATE; no specific new trend in this respect was recognized.

NOTE: The question of unwanted release was explored with the help of the Users that answered to exploratory questions regarding (the corresponding material can be seen on the item D 1.11.1):

- Number of unwanted (unnecessary-accidental) releases of fire protection per unit per year,
- Outage duration that resulted due to clean up and
- Indication of the reasons of the unwanted releases as far as known.

## H2/11 - Is the fire ext. released immediately?

The involved questions were the following:

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	11	11	6	
UPDATE Groups				
Group 1 – Users	D 1.12	21	9	From 35 answers 5 blank
Group 2 – Manufacturers				
Group 3 – Insurers				
Group 6 – Consulting				

On both surveys the tendency is the immediate release, but the survey did not allow distinguishing this answer regarding the extinguishing media used. It is to expect that by using CO<sub>2</sub> in assisted plants the release follows a certain time delay.

On Dr. Kranz's work an additional question was stated: "What step first?" which got 7 answers "*Trip unit and field breaker first.*"

On the other hand on the UPDATE an open question to the item D 1.12 was stated: "If No, please inform the steps of releasing the extinguishing media" this question explored the cases in which a delay in the release of the extinguishing media is set. The answers received were categorized, and the complete versions can be found in the corresponding annex of the Group 1:

<b>1.12) In an event of fire is detected by the devices installed (e.g. Smoke, heat etc), will extinguishing media release immediately without any delay or any manual interference?</b>		
<b>If No, please inform the steps of releasing the extinguishing media:</b>		
Grouping A	Alarm (acoustic and optical) comes prior to release	1
Grouping B	Manual release	2
Grouping C	Time delay for release	3
Grouping D	Answer does not match the subject asked (not considered for the graphic)	3
<b>Total of answered questions</b>		<b>9</b>

## H2/12 - Does the fire extinguishing also fight fire in the bearing and at what conditions?

This item involved the following questions:

	Involved question	Y	N	Don't know	Remarks
Dr. Kranz's Questionnaire	12	7	7		
UPDATE Groups					
Group 1 – Users	D 1.13.1	5	24	6	No blank answers
Group 2 – Manufacturers					
Group 3 – Insurers					
Group 6 – Consulting					

It is interesting to see that the proportional quantity of users that the indicated that their bearings are protected by the GFP reduced from the 50% Dr. Kranz's work to 14% on the UPDATE.

The UPDATE's question "D 1.13 - Do you consider bearings as a potential fire hazard for generators?" shows the present tendency by getting 8 Yes and 27 No. This confirms the tendency indicated above.

## H2/ 13 - Do you specify provisions to remove fire ext. media?

This item involves the following questions:

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	13	7	7	
UPDATE Groups				
Group 1 – Users	D 1.14	15	16	From 35 answers 4 blank
Group 2 – Manufacturers				
Group 3 – Insurers				
Group 6 – Consulting				

Both surveys showed a tie situation and no difference between before and after occurred.

On the UPDATE two exploratory open questions were made, and the corresponding results are reproduced below:

<b>Do you specify provisions to remove fire extinguishing media? If yes, <u>for water</u>: does it include provisions for decontamination in case of water used for extinguishing a fire? Please specify here:</b>		
Grouping A	Drainage of water to decontamination - oil water separator	2
Grouping B	No decontamination foreseen	4
<b>Total of answered questions</b>		<b>6</b>

This question was stated in order to evaluate provisions to respect environmental precautions regarding the waister water from an extinguishing process. In spite of the little number of answers we can say that very little care with the environment is being taken in this respect. It is to expect that this situation will change in the next years with the growing environmental awareness process.

And

<b>Do you specify provisions to remove fire extinguishing media? If yes, <u>for CO<sub>2</sub></u>: do you have an exhaust system that removes the media out of the room? Please specify here:</b>		
Grouping A	Fix exhaust system	8
Grouping B	Portable exhaust system	3
Grouping C	Separate exhaust channels	1
Grouping D	No separate exhaust system available	1
<b>Total of answered questions</b>		<b>13</b>

As expected, considering the security of personnel the extraction of CO<sub>2</sub> receives more attention from the Users involved. The most installed alternative is the fix exhaust system.

The complete answers can be seen on the question D 1.14 and its annexes.

## H2/ 13.1 - **What is the maximum number of machines protected by one storage?**

This item involves the following questions:

	Involved question	Remarks
Dr. Kranz's Questionnaire	13.1	
UPDATE Groups		
Group 1 – Users	D 1.16	Composed table
Group 2 – Manufacturers		
Group 3 – Insurers		
Group 6 – Consulting		

The answers received by Dr. Kranz were not separated by type of extinguishing media this fact does not allow the comparison with the new data gathered by the UPDATE. The complete data can be seen below for Dr. Kranz's question 13.1 and in the Group 1's question D 1.16.

## H2/ 14 - Future trend for extinguishing media?

This item involves the following questions:

	Involved question	Remarks
Dr. Kranz Questionnaire	14	
UPDATE Groups		
Group 1 – Users	D 1.17	
Group 2 – Manufacturers		
Group 3 – Insurers		
Group 6 – Consulting		

Dr. Kranz's work showed only two alternatives and their combination as future trend for extinguishing media:

14 - Future trend for extinguishing media?		
Grouping A	Halon	2
Grouping B	Water	2
Grouping C	Halon; Water	4
<b>Total of answered questions</b>		<b>8</b>

And one of them was banished due to the Ozone layer depletion: Halon.

Since the UPDATE's Group 1 had more participants and an open question was stated the answers for the question D 1.17 resulted more diversified:

D 1.17) What is the future trend for extinguishing media?		
Grouping A	CO2 – remains	2
Grouping B	Water – remains	7
Grouping C	Fire extinguisher (dry chemical powder) –remains	1
Grouping D	Foam extinguisher	1
Grouping E	New media like chemical dust, CO2 and halogen composites	1
Grouping F	Inert gas (INERGEN and alike)	2
Grouping G	Inert gas (INERGEN and alike) and water	2
Grouping H	Inert gas, water or none	1
Grouping I	NO fire protection at all	7
Grouping J	NO evolution foreseen	1
Grouping K	Answer does not match the subject asked (not considered for the graphic)	1
<b>Total of answered questions</b>		<b>26</b>

Comparing the results “Water” appears with evidence in the UPDATE and divides with the alternative “NO fire protection at all” the first place of the statistics.

On a newer trend Inergen appeared in two categories, alone and with water. Inergen seems to be the reasonable, environmentally correct and safe for the human's alternative for extinguishing media.

For more details on the complete data received please refer to the annexes of the question D 1.17.

## H2/ 14.1- What is the future trend for fire detection?

This item involves the following questions:

	Involved question	Remarks
Dr. Kranz's Questionnaire	14.1	
UPDATE Groups		
Group 1 – Users	D 1.18	
Group 2 - Manufacturers		
Group 3 – Insurers		
Group 6 – Consulting		

Dr. Kranz's work sowed two alternatives:

14.1- Future trend for fire detection?		
Grouping A	Heat sensing cable (new temperature detectors)	3
Grouping B	Ionic smoke detectors	4
<b>Total of answered questions</b>		<b>7</b>

The heat sensing cables are used mainly in electrical panels and bus-ducts and the ionic smoke sensors are used in generators housings.

The UPDATE's Group 1 showed the following answers to this question:

D 1.18 - What is the future trend for fire detection?		
Grouping A	Heat and smoke detectors – remain	6
Grouping B	Advanced smoke detectors (VESDA)	2
Grouping C	Smoke detectors –remain	3
Grouping D	NO perspective of sensor's evolution	2
Grouping E	Combination of detectors and relays monitored by an automatic system (e.g.. artificial intelligence)	3
Grouping F	Chemical analysis of cooling air	1
Grouping G	HAD and split phase	1
Grouping H	Incipient and early detection in combination of heat and smoke	1
Grouping I	Electric arc detection	1
Grouping J	NO detection and NO GFP	3
Grouping K	Answer does not match the subject asked (not considered for the graphic)	2
<b>Total of answered questions</b>		<b>25</b>

We point out again the use of VESDA (smoke aspiration detectors). With the evolution of computing and chemical sensors it may be that the alternative "Chemical analysis of cooling air" will become feasible. The use of artificial intelligence in conjunction with detectors and protection relays is also a possible trend.

For more details on the complete data received please refer to the annexes of the question D 1.18.

## H2/ 15 - Is there a need for international standard?

This item involves the following questions:

	Involved question	Y	N	Remarks
Dr. Kranz's Questionnaire	15	5	11	
UPDATE Groups				
Group 1 – Users	D 1.20	7	18	From 35 answers 10 blank
Group 2 – Manufacturers				
Group 3 – Insurers				
Group 6 – Consulting	G 6.5.3	3	4	From 9 answers 2 blank

On a general point of view there was no change between Dr. Kranz's results and those from the Group 1 – Users (question D 1.20) and Group 6 – Consulting (question G 6.5.3) – according to these answers there is no need of a new International Standard.

### **H3 - Comments on the original written conclusions and the present UPDATE:**

We took the original conclusions stated in Dr. Kranz's work as published on the CIGRÉ's Magazine ELECTRA N° 103 and prepared, when applicable, a comparison stating the conclusions derived from the present UPDATE that is presented in the form of a table that allows an easy a direct overview.

<b>Nr.</b>	<b><i>Original conclusions of the former Generator Fire Protection work made by Dr. Kranz-1981 and Published by Electra 103 in 1985:</i></b>	<b>UPDATE comments for the Group-1 Users, based upon the data received and its evaluation - 2010:</b>
01	<i>With the absence of international standards or recommendations the philosophy for application of fire extinguishing Installations vary considerably. The decisions are mostly taken individually based on positive or negative experience, tradition, or legislation and insurance requirements.</i>	The basic idea of Dr. Kranz's Conclusions (DKC) is still valid and we add to that the fact that there are big differences concerning having or not specific knowledge and experience on fire protection principles considering some of the received contributions. Here more information based upon fire protection principles and exchange of experience seems to be advisable.
02	<i>In some cases the application is restricted to vertical generators with closed air circuits or to machines operated in unmanned plants.</i>	The application range nowadays shows that there are other criteria for the application of GFP then those shown on DKC as size of the units. The present UPDATE (TPU) shows that GFP is also applied in some open generators by means of provisions to close the volume for the extinguishing media application.
03	<i>The installed fire extinguishing equipments in general do not take into consideration the bearings in special. But oil dust or oil coated surfaces represent a danger for fire.</i>	This situation was reported on received comments thus this situation is still existing and reported as valid nowadays.
04	<i>Although modern insulations are mostly</i>	The DKC conclusion seems to

	<p><i>considered to be non-inflammable, fire retardant or self-extinguishable, accidents have shown that these materials may burn, given sufficient temperature and heat input by the igniting arc and then by the burning insulation itself promoting the extension of fire, if there is enough oxygen. This experience, gained by accident, has been proved by relevant tests and has led to a later installation of fire extinguishing equipment in some plants. This experience may not necessarily apply to all modern insulation systems...</i></p>	<p>continue valid and there may be that the divulgation made by some manufacturers that their machines are inflammable (this affirmation does not have a scientific confirmation) may bring an increased risk to power plants not equipped with GFP. This risk is highlighted by the following comment: <i>“As one can recognize, the oxygen and heat are present if no suppression is available. The question then becomes whether or not the fuel exists to support a chemical reaction – according to the Fire scheme. Manufacturers suggest that the current materials (epoxy based materials) will not burn if the heat is removed.</i></p> <p><i>However, many times the heat is so intense that even if the "flash" that started the ignition is removed, the epoxy forms combustible gas (in the contained environment of the air housing) via a chemical reaction, and it becomes the fuel source.”</i></p> <p><b>IMPORTANT: the IEC Standards recall the following when deals with flammability: <i>The small-scale laboratory test used in this standard for assigning a flammability category is primarily for monitoring consistency of production of laminates. The results so obtained should not in any circumstances be considered as an overall indication of the potential fire hazards presented by these laminates under actual conditions of use.</i></b></p>
05	<p><i>CO<sub>2</sub> is the most used medium for extinguishing and in some countries the USA National Fire Protection Code NFPA 12, is occasionally considered for CO<sub>2</sub> equipment. CO<sub>2</sub> is asphyxiating. It is heavier than air. If a leakage occurs it can accumulate in lower areas of the power station. It is also dangerous, if CO<sub>2</sub> is released when personnel are inside the generator pit. In order to prevent asphyxiating accident to men specific measures are taken. Among these are:</i></p> <ul style="list-style-type: none"> <li>- alarm</li> <li>- visual indication of safe</li> </ul>	<p>In addition to these precautions the continuous supervision of the CO<sub>2</sub> bottles weight is used to control any leakage on the bottles. The other measures are still good technical practice.</p>

	<p><i>and/or unsafe conditions</i></p> <ul style="list-style-type: none"> <li>- <i>blocking the release of CO<sub>2</sub> whenever it is necessary to enter into CO<sub>2</sub> protected areas</i></li> <li>- <i>only personnel trained in fire fighting and equipped with breathing apparatus are permitted to enter the enclosure of a burning generator</i></li> <li>- <i>after application of CO<sub>2</sub> to ventilate the ambient. No damage to components is expected from CO<sub>2</sub>.</i></li> </ul>	
06	<p><i>Water spray is the other extinguishing medium regarded as efficient. Its use may be harmful to stator laminations and windings. But experience has not (almost) confirmed this, obviously due to the cleanliness of the used water. Dirt in the machine may however have a harmful influence. Older thermoplastic insulation systems are not considered as waterproof.</i></p>	<p>Comments received confirm the occurrence of problems with laminations after water being used as extinguishing media, even in machines with stator core treated with special sealing enamel. Same applies to damages to pole core laminations.</p>
07	<p><i>Halon is very seldom corrosive gases might be produced when Halon comes into contact with the igniting arc.</i></p>	<p>The possibility of production of corrosive gases as described by DKC is correct; but nowadays the use of Halon for such applications was forbidden due to the Ozon Layer depletion caused by Bromofluorcarbon. There are materials developed for the Halon substitution as Inergen, for instance.</p>
08	<p><i>The fire extinguishing medium should mostly be released automatically and manually. However one answer says: Water spray can only be applied to a generator fire after permission has been granted by authorized personnel. A hose connection must then be made before the water can be applied. This procedure ensures that water is not applied unnecessarily or accidentally to a live machine.</i></p>	<p>The release systems that allow automatic and manual release are the most preferred nowadays. No specific comment on water release pre-conditions was received.</p>
09	<p><i>In order to avoid unnecessary release the kind of detecting the fire is of high importance. A wide variety of methods is used single or in combination:</i></p> <ul style="list-style-type: none"> <li>- <i>plant personnel</i></li> <li>- <i>heat detectors, temperature sensors</i></li> </ul>	<p>Talking about detection a new system was added to the smoke detection that is the VESDA that was developed for high value asset ambients, as Data Storage Centers, and now received a version for hydro generators protection; with equally good results.</p>

	<p>- smoke detectors, ionization detectors the latter two often is combination or with</p> <p>- electrical protection relays such as ground fault or differential relay</p>	
10	<p><i>For the problem how to prevent unnecessary release of the fire extinguishing at false alarm the working group came to the conclusion:</i></p> <p><i>As a severe fire in a generator can only be ignited by an electrical fault producing an arc the release of the fire extinguishing media should be interlocked with the electrical protection system of the generator.</i></p>	This trend was fully supported by the UPDATE.
11	<p><i>Although the bearings contain burnable oil the fire extinguishing installation in most or even all cases does not specifically protect the bearings unless the bearings are by hazard located in the protected area. A fire in the bearings however is considered very unlikely. But as oil containers in a power station are often protected with a CO<sub>2</sub> fire protection equipment also the bearings of vertical machines should be protected at least if high pressure tube-lines are situated outside the bearing housing.</i></p>	This is good technical practice.
12	<p><i>After the fire extinguishing medium is released and the fire is extinguished the medium is removed in different ways by:</i></p> <p><i>- fans, fix or mobile - gravity drains - special ducts with or without fans - compressed air - no special means</i></p>	This is done in CO <sub>2</sub> applications as well as in Water applications.
13	<p><i>The number of machines protected by one common storage differs widely using one or two CO<sub>2</sub> banks in many combinations for 1 up to 10 machines.</i></p>	In the UPDATE for the case of CO <sub>2</sub> we got up to 7 machines per storage, but without the indication if it is with high or low pressure tanks. It is common to see high pressure tanks installations, one main battery and one reserve attending up to 4 units. In the case of water there is usually no limit.
14	<p><i>The considerations on future trends are diverging. As a new medium however only Bromochlorodifluoromethan is considered by one user in AUS. There are future prospects for Halon but it is reminded that more investigation must be executed regarding the corrosive gases originated in</i></p>	As said before Halon was banned, it is an excellent extinguishing media but, besides the Ozone layer depletion problem it can generate corrosion on protected equipment. It is still allowed only for military and aeronautical applications.

	<i>the arc and their influence on the various materials in a generator. Experience of application of both media is not known.</i>	
15	<i>For detecting equipment a variety of instrumentation is for disposal. Ionization detectors are supposed to be rather too sensitive and need interlocking with the electrical protection system to avoid unnecessary release.</i>	The problem of dust inside the generator chamber does complicate the smoke detection. But new detection methods like VESDA are starting to be used.
16	<i>There is only little interest for new standards in the field of fire extinguishing in salient pole machines. But this report collecting the experience from a number of countries and summarizing the discussion of the Working Group may be of use as a general guideline.</i>	On the UPDATE side, among others, there is interest on recommendations and on the establishment of a permanent Group at CIGRÉ to deal with this subject. A key issue would be the discussion of the philosophy to be applied in GFP applications.

#### **H4 - The GFP from an ideal perspective:**

As already said the use of GFP is defined in standards, is defended by ones and opposed by others, there are many different approaches to this subject. On the other hand both surveys, the one made by Dr. Kranz and the present UPDATE, allow to compose an ideal perspective based upon the present state of the art on the GFP technology and the good practices indicated on several comments throughout mainly the UPDATE. Let's see how it would look like:

##### **H4.1) To use GFP or not?**

Here the answer is similar to the one that is taken concerning insuring or not the power plant. The use of GFP provided that its design, materials, erection do comply with applicable standards and best technical practices and that it will be well maintained may assure the shortest possible outage should a fire accident occur due to the reduction of the accident's consequences and faster return of the unit to grid due to less required repair works.

##### **H4.2) Which extinguishing media shall be used?**

The choice of the media shall contemplate aspects regarding man and machine preservation and keep the focus on a healthy costs balance. Starting with the machine preservation a gaseous extinguishing media is adequate provided its deployment will not damage the housing's components and thus assuring that the required concentration during the established time will be applied, allowing the adequate action of the extinguishing media. This implies, for instance, in an effective design with pressure relief openings when required. It is desired that the deployment will not leave any contaminating or corroding residue. Regarding the man preservation it is expected that the extinguishing will bring no harm due to the media itself to man involved in the risk area.

The media that showed up in the UPDATE bringing these characteristics is Inergen, an inert gas, or any similar inert gas available. No residue and no harm to men.

##### **H4.3) Which detection, control and manual or automatic releases?**

The thermal and smoke detection are still adequate, and the modern VESDA suction type smoke detection allows more accurate results. For the control the state of the art systems do present a logic control that interlocks the sensors signals with the electrical protection

relays of the generator according to a defined logic that shall also avoid unwanted releases. For manned plants the release shall allow manual or automatic control. For unmanned plants it is advisable to let the release on automatic.

This ideal scheme is suited also for underground power plants since the extinguishing media itself does not impose harm to human health, but one shall not forget that any fire accident area is a risk area by itself and shall be abandoned immediately and safely.

End of the Volume I, on the Volume II are the Annexes.