



**CONCLUSIONS OF THE
HYDROGENERATORS FIRE PROTECTION UPDATE
COMPARISON WITH DR. KRANZ'S WORK
(April 2010)**

Convener: Alexander Gromow (BR)

H - 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 29 years ago 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		65 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 four 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.

This UPDATE did grow to 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 item:		
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	5014

H 1: This work is composed by the following sections:

INITIAL DRAFT OF THE QUESTIONNAIRE REPORT ON HYDROGENERATORS FIRE PROTECTION UPDATE

Composed by:

A – Introduction

B – Methodology

C – Individual item analysis

STUDY OF THE GROUP 1- USERS' ANSWERS

Composed by:

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

Annexes D) The original complete statistical tables that support the item D

STUDY OF THE GROUP 2- MANUFACTURERS' ANSWERS

Composed by:

E 2 - Questionnaire with focus on Generator Manufacturers

Annexes E) The original complete statistical tables that support the item E

STUDY OF THE GROUP 3- INSURERS' ANSWERS

Composed by:

F 3 - Questionnaire with focus on Insurance Companies, Reinsurance Companies or Insurance Brokers

Annexes F) The original complete statistical tables that support the item F

STUDY OF THE GROUP 6- CONSULTINGS' ANSWERS

Composed by:

G 6 - Questionnaire with focus on Consulting Companies

Annexes G) The original complete statistical tables that support the item G

H 2 – **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 significative 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:

2.1 What are the reasons (for recommending GFP)?		
Grouping A	Satisfactory experience, oil dust, unmanned stations	5
Grouping B	Required by National Standards GOST 5615-80 (USSR)	1
Total of answered questions		6

Five from the six received contributions recall for satisfactory experience with GFP as the reason for recommend its use.

The analysis of the exploratory open question shows the present evolution on this question; this can be seen on the item C.1.3 – The basic question about the recommendation of the installation of Generator Fire Protection, now analysed through control descriptive questions of the INITIAL DRAFT OF THE QUESTIONNAIRE REPORT ON HYDROGENERATORS FIRE PROTECTION UPDATE. 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 recall 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. Two additional exploratory questions were made and the corresponding results are available on the item C.1.3.3 of the above mentioned INITIAL DRAFT.

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:

3.1 What are the reasons for change in the opinion?		
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
Total of answered questions		10

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 CO₂

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. 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.” 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 ₂	8	101			3	104
H ₂ O		91			5	96
CO ₂ +H ₂ O	4					
CO ₂ - inland and H ₂ 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:

	Dr. Kranz's Questionnaire	UPDATE Groups				UPDATE Totals
		Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	5	D 1.7				
Alternatives:						
CO ₂	6	12				12
H ₂ O	1	7				7
CO ₂ +H ₂ 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 CO₂ was considered to be the most efficient extinguishing media. In fact CO₂ 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.

	Dr. Kranz's Questionnaire	UPDATE Groups				UPDATE Totals
		Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	5.1	D 1.7.1				
Alternatives:						
CO ₂		1				1
H ₂ O	4	16				16
CO ₂ +H ₂ 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 upgrade this aspect was stated as an open question:

	Dr. Kranz's Questionnaire	UPDATE Groups				UPDATE Totals
		Group 1 – Users	Group 2 - Manufacturers	Group 3 - Insurers	Group 6 - Consulting	
Involved question	5.2	D 1.7.2				UPDATE Totals
Alternatives:						
CO ₂		28				28
H ₂ O						
Halon		4				4
N ₂		3				3
Foam		1				1
Any Gas		1				1
Chemical powder		1				1
Nothing		1				1

CO₂ was indicated by the Users as being the most harmful media for humans. And this makes sense due to the CO₂'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 CO₂ 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:

6 Do you specify measures to prevent accidents to men? Additional comments:		
Grouping A	Alarm and notes	1
Grouping B	Alarm and notes + Interlock for entry in CO ₂ protected area	2
Grouping C	Interlock for entry in CO ₂ protected area	3
Grouping D	Interlock for CO ₂ , none for water spray	1
Total of answered questions		7

On the Dr. Kranz's work the focus was given to alarm and interlock to make the CO₂ 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:

Grouping	Legend	Quantity
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 ₂) interlocking, disconnect system before going in to room - for inspection or maintenance	7
Grouping D	CO ₂ systems are not acceptable	1
Grouping E	Forbid to enter housing after CO ₂ 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 ₂ protected areas when system is activated	2
Grouping J	Eliminate CO ₂ systems when relay system is sufficient	1
Grouping K	Implementation of fire compartments on power plants	1
Grouping L	Planning to remove CO ₂	1
Grouping M	Answer does not match the subject asked	1
Grouping N	Blank	9
Total of answered questions		35

In the UPDATE new aspects did come in to discussion, as training, generators' area entrance regulations, and elimination of CO₂ 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:

1.8.1) Do you specify measures to prevent damage to machine? If yes, please specify:		
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 ₂ 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
Total of additional information given		22

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:

1.9.1) What is your opinion or preferred method, as to how the generator fire extinguishing system should be released?		
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
Total of answered questions		35

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:

		UPDATE Groups				
	Dr. Kranz's Questionnaire	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	UPDATE Totals
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)":

10 - Additional explanations to the question: What procedure?		
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
Total of answered questions		5

On the UPDATE we got the following situation:

For the Group 1 – Users:

D 1.11 - How do you prevent unwanted (unnecessary-accidental) release of generator fire extinguishing system?		
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 ₂ 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:

2.4.2) Do you recommend any specific detection and control system to minimize unwanted fire extinguishing system operation?		
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
Total of answered questions		10

For the Group 6 – Consulting:

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)?	
Company	Result
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 CO₂ 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:

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?		
If No, please inform the steps of releasing the extinguishing media:		
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
Total of answered questions		9

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:

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:		
Grouping A	Drainage of water to decontamination - oil water separator	2
Grouping B	No decontamination foreseen	4
Total of answered questions		6

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

Do you specify provisions to remove fire extinguishing media? If yes, <u>for CO₂</u>: 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
Total of answered questions		13

As expected, considering the security of personnel the extraction of CO₂ 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
Total of answered questions		8

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	1

graphic)	
Total of answered questions	26

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 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
Total of answered questions		7

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
Total of answered questions		25

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.

Nr.	Original conclusions of the former Generator Fire Protection work mad by Dr. Kranz-1981:	UPDATE comments for the Group-1 Users, based upon the data received and its evaluation - 2010:
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	<p><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></p>	<p>This situation was reported on received comments thus this situation is still existing and reported as valid nowadays.</p>
04	<p><i>Although modern insulations are mostly 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>The DKC conclusion seems to 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: "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.</p> <p>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."</p> <p>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></p>
05	<p><i>CO₂ is the most used medium for extinguishing and in some countries the USA National Fire Protection Code NFPA 12, is occasionally considered for CO₂ equipment. CO₂ 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 CO₂ 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"> - alarm 	<p>In addition to these precautions the continuous supervision of the CO₂ bottles weight is used to control any leakage on the bottles. The other measures are still good technical practice.</p>

	<ul style="list-style-type: none"> - <i>visual indication of safe and/or unsafe conditions</i> - <i>blocking the release of CO₂ whenever it is necessary to enter into CO₂ protected areas</i> - <i>only personnel trained in fire fighting and equipped with breathing apparatus are permitted to enter the enclosure of a burning generator</i> - <i>after application of CO₂ to ventilate the ambient. No damage to components is expected from CO₂.</i> 	
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.</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"> - <i>plant personnel</i> - <i>heat detectors, temperature sensors</i> - <i>smoke detectors, ionization detectors the latter two often is combination or with</i> - <i>electrical protection relays such as</i> 	<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>

	<i>ground fault or differential relay</i>	
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 CO₂ 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 ₂ 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 CO₂ banks in many combinations for 1 up to 10 machines.</i></p>	In the UPDATE for the case of CO ₂ 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 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 the arc and their influence on the various materials in a generator. Experience of application of both media is not known.</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.
15	<p><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</i></p>	The problem of dust inside the generator chamber does complicate the smoke detection. But new detection methods like VESDA are

	<i>electrical protection system to avoid unnecessary release.</i>	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.

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.

H5 - Annexes to conclusions:

Rework of the original table “Condensation of the Answers to the Questionnaire” part of the Survey: “Fire Extinguishing in Large Salient Pole Machines” by Dr. Kranz.

In order to bring the original Dr. Kranz’s table to the same presentation an analysis level used in the present UPDATE each question was converted as stated below. The work was done taking as source a copy received at the beginning of this work. We reproduce the original copy for the sake of completion of this work:

QUOTE

CIGRÉ	Condensation of the Answers to the Questionnaire
WG 11-02	“Fire Extinguishing in Large Salient Pole Machines”

Country	A	AUS	B	BR	CDN	CH	CS	F	I	J	N	S	UK	USS R
Nr of answers	1	5	1	6	3	6	1	1	1	1	9	1	3	1
Questions														
1. Are there standards? What Standards?	No	Yes NFPA 12 1)	No	No	Yes NFPA 12 1)	No NFPA 12 1)	No	No	No	No	No	No	No	No
2. Do you recommend or install fire ext. inst.? What are the reasons?	2) -	3) 5)	No -	Yes 5)	Yes 5)	Yes 3) 5)	4) -	3) -	4) -	Yes -	5Yes 4No (5)	No -	2) -	Yes 6)
3. Has there been a different opinion in the past? What are the reasons of the change in opinion?	Yes 7)	Yes 8)	Yes 8)	No 8)	No	No	Yes 9)	Yes 9)	No	No	Yes 8+9)	Yes 9)	No	No (9)
4. What system and ext. media have been installed recently?	CO ₂	CO ₂ 10)	CO ₂	CO ₂	10) (CO ₂)	11)	CO ₂	11)	CO ₂	CO ₂ (10)	CO ₂	CO ₂	CO ₂	10) CO ₂
5. Efficient media Media harmful to machine Media dangerous to human health	CO ₂ H ₂ O -	CO ₂ - -	- - -	CO ₂ H ₂ O -	CO ₂ + H ₂ O (H ₂ O) -	CO ₂ - -	H ₂ O+ CO ₂ (H ₂ O) -	- - -	CO ₂ - -	- - -	- - -	12) - -	H ₂ O+ CO ₂ - -	H ₂ O - -
6. Do you specify measures to prevent accidents to men? Damage to machine?	13) -	13+ 14) -	- -	13+ 14) -	Yes -	14) -	No -	Yes -	14) -	15) -	Yes -	Yes -	14) -	No -
7. Should fire ext. be released automatically? Manually? Auto+Manually?	- - Yes	- 1Yes 4Yes	- - Yes	- - Yes	- 16) Yes	- - Yes	- - Yes	- - Yes	- - Yes	- - Yes	- - Yes	- - Yes	- - Yes	- - Yes
8. How is the fire detected by personnel only? By instruments and which ones?	17)	19) 18)	20)	17+ 18)	17+ 18)	18+ 20)	20)	17)	17)	17)	17+ 20)	20)	17)	Yes -
9. Is the fire ext. released by an other device then	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	2No 1Yes	No

heat or smoke detectors? What device?	21)	21)	22)	21+ 22)	23)	21)		22)	22)			22)	23a)	
10. Do you specify procedure to prevent unnecessary release? What procedure?	No	Yes	No	No	No	No	No	No	No	Yes	No	Yes	Yes	No
		24)		24+ 23)	24)	24)							23a+ 25)	26)

Legend:

- 1) Not generally applied
- 2) No, but in special cases yes
- 3) Yes for vertical machines with closed air circuit
- 4) At user's wish only
- 5) Satisfactory experience, oil dust, unmanned stations
- 6) Required by national standard COST 5615-80
- 7) Pollution by oil dust
- 8) With sufficient heat and oxygen also modern insulation is flammable
- 9) Use of modern self-extinguishable insulation
- 10) Water spray
- 11) CO2 in inland, water spray abroad
- 12) CO2 is not efficient if generator housing is not tight!
- 13) Alarm and notes
- 14) Interlock for entry in CO2 protected area
- 15) Interlock for CO2, none for water spray
- 16) With water as extinguishing media, only manual release
- 17) Temperature and smoke sensors = smoke detectors = probe
- 18) Temperature and ionization detectors = ionic smoke detectors
- 19) With water as extinguishing media, only detection by personnel
- 20) Temperature detectors
- 21) Differential relay
- 22) Differential relay and stator ground fault relay
- 23) Differential relay and winding fault relay
- 23a) Electric protection relays
- 24) Interlocking with electrical protection relays
- 25) Release after visual confirmation
- ~~26) Disconnected hose with water as extinguishing media~~
- 27) Trip unit and field breaker first
- 28) With CO2 as extinguishing media and bearings in the protected area
- 29) Halon
- 30) Water
- 31) Heat sensing cable (new temperature detectors)
- 32) Ionic smoke detectors
- 33) No standards but recommendations
- 34) Yes for CO2 gas cylinders (standardization)

UNQUOTE

Dr. Kranz's table was made using numbered observations which were stated at the end. In the rework these observations, when applicable, were stated together with the corresponding evaluation table:

Question: 1- Are there Standards?

Check-box part:

1- Are there Standards?			
		Yes	No

Austria	A		1
Australia	AUS	1	
Belgium	B		1
Brazil	BR		1
Canada	CDN	1	
Switzerland	CH		1
Czechoslovakia	CS		1
France	F		1
Italy	I		1
Japan	J		1
Norway	N		1
Sweden	SUI		1
Great Britain	UK		1
Soviet Union	USSR		1

2	12
---	----

Open question: What Standards?

1.1 - What Standards?			
Austria	A	Comment	Explanation
Australia	AUS		
Belgium	B	1)	1) NFPA 12 - Not generally applied
Brazil	BR		
Canada	CDN		
Switzerland	CH	1)	
Czechoslovakia	CS	1)	
France	F		
Italy	I		
Japan	J		
Norway	N		
Sweden	SUI		
Great Britain	UK		
Soviet Union	USSR		

Question: 2 - Do you recommend or install fire ext. inst.?

2- Do you recommend or install fire extinction?			
		Yes	No
Austria	A	1	1
Australia	AUS	1	
Belgium	B		1
Brazil	BR	1	
Canada	CDN	1	
Switzerland	CH	1	
Czechoslovakia	CS	1	
France	F	1	
Italy	I	1	
Japan	J	1	
Norway	N	5	4
Sweden	SUI		1

Additional comments:	
Comment	Explanation
2)	2) No but in special cases Yes
3)	3) Yes for vertical machines with closed air circuit
3)	
4)	4) At user's Wish only
3)	
4)	

Great Britain	UK	1	1	2)	
Soviet Union	USSR	1			

16	8
----	---

Open question: 2.1 - What are the reasons?

2.1 - What are the reasons?			
		Comment	Explanation
Austria	A		
Australia	AUS	5)	5) Satisfactory experience, oil dust, unmanned stations
Belgium	B		
Brazil	BR	5)	
Canada	CDN	5)	
Switzerland	CH	5)	
Czechoslovakia	CS		
France	F		
Italy	I		
Japan	J		
Norway	N	5)	
Sweden	SUI		
Great Britain	UK		
Soviet Union	USSR	6)	6) Required by National Standards GOST 5615-80

Question: 3 - Has there been a different opinion in the past?

3- Has there been a different opinion in the past?			
		Yes	No
Austria	A	1	
Australia	AUS	1	
Belgium	B	1	
Brazil	BR		1
Canada	CDN		1
Switzerland	CH		1
Czechoslovakia	CS	1	
France	F	1	
Italy	I		1
Japan	J		1
Norway	N	1	
Sweden	S	1	
Great Britain	UK		1
Soviet Union	USSR		1

7	7
---	---

Open question: 3.1 - What are the reasons for change in the opinion?

What are the reasons for change in the opinion?			
		Comment	Explanation
Austria	A	7)	7) Pollution by oil dust

Italy	I	1		
Japan	J	-	-	-
Norway	N	-	-	-
Sweden	SUI	1		
Great Britain	UK			1
Soviet Union	USSR		1	

12)	12) CO ₂ is not efficient if generator housing is not tight!

6	1	3
---	---	---

Question: 5.1-Media harmful to machine

5.1-Media harmful to machine				
		CO ₂	H ₂ O	CO ₂ + H ₂ O
Austria	A		1	
Australia	AUS		-	
Belgium	B		-	
Brazil	BR		1	
Canada	CDN		1	
Switzerland	CH		-	
Czechoslovakia	CS		1	
France	F		-	
Italy	I		-	
Japan	J		-	
Norway	N		-	
Sweden	SUI		-	
Great Britain	UK		-	
Soviet Union	USSR		-	

0	4	0
---	---	---

Question: 5.2- Media dangerous to human health

5.2- Media dangerous to human health				
		CO ₂	CO ₂ + H ₂ O	CO ₂ inland H ₂ O abroad
Austria	A	-	-	-
Australia	AUS	-	-	-
Belgium	B	-	-	-
Brazil	BR	-	-	-
Canada	CDN	-	-	-
Switzerland	CH	-	-	-
Czechoslovakia	CS	-	-	-
France	F	-	-	-
Italy	I	-	-	-
Japan	J	-	-	-
Norway	N	-	-	-
Sweden	SUI	-	-	-
Great Britain	UK	-	-	-
Soviet Union	USSR	-	-	-

0	0	0
---	---	---

Question: 6- Do you specify measures to prevent accidents to men?

6- Do you specify measures to prevent accidents to men?			
		Yes	No
Austria	A	1	
Australia	AUS	1	
Belgium	B	-	-
Brazil	BR	1	
Canada	CDN	1	
Switzerland	CH	1	
Czechoslovakia	CS		1
France	F	1	
Italy	I	1	
Japan	J	1	
Norway	N	1	
Sweden	SUI	1	
Great Britain	UK	1	
Soviet Union	USSR		1

Additional comments	
Com-ment	Explanation
13)	13) Alarm and notes
13)+14)	13)+14) Interlock for entry in C02 protected area
13)+14)	
14)	
14)	
15)	15) Interlock for C02, none for water spray
14)	

11	2
----	---

Question: 6.1- Damage to machine?

6.1- Damage to machine?			
		Yes	No
Austria	A	-	-
Australia	AUS	-	-
Belgium	B	-	-
Brazil	BR	-	-
Canada	CDN	-	-
Switzerland	CH	-	-
Czechoslovakia	CS	-	-
France	F	-	-
Italy	I	-	-
Japan	J	-	-
Norway	N	-	-
Sweden	SUI	-	-
Great Britain	UK	-	-
Soviet Union	USSR	-	-

0	0
---	---

Question: 7- Should fire ext. be released automatically?

7- Should fire ext. be released automatically?
--

		Yes	No
Austria	A	-	-
Australia	AUS	-	-
Belgium	B	-	-
Brazil	BR	-	-
Canada	CDN	-	-
Switzerland	CH	-	-
Czechoslovakia	CS	-	-
France	F	-	-
Italy	I	-	-
Japan	J	-	-
Norway	N	-	-
Sweden	SUI	-	-
Great Britain	UK	-	-
Soviet Union	USSR	-	-

0	0
---	---

Question: 7.1 - Should fire ext. be released manually?

7.1 - Should fire ext. be released Manually?			
		Yes	No
Austria	A	-	-
Australia	AUS	1	-
Belgium	B	-	-
Brazil	BR	-	-
Canada	CDN	1	-
Switzerland	CH	-	-
Czechoslovakia	CS	-	-
France	F	-	-
Italy	I	-	-
Japan	J	-	-
Norway	N	-	-
Sweden	SUI	-	-
Great Britain	UK	-	-
Soviet Union	USSR	1	-

Additional comments:	
Com ment	Explanation
16)	16) With water as extinguishing media, only manual release

Question: 7.2 - Should fire ext. be released automatically + manually?

7.2 - Should fire ext. be released automatically + manually?			
		Yes	No
Austria	A	1	-
Australia	AUS	4	-
Belgium	B	1	-
Brazil	BR	1	-
Canada	CDN	1	-
Switzerland	CH	1	-
Czechoslovakia	CS	1	-
France	F	1	-
Italy	I	1	-
Japan	J	1	-

Norway	N	1	-
Sweden	SUI	1	-
Great Britain	UK	1	-
Soviet Union	USSR	-	-

16	0
----	---

Question: 8- How is the fire detected?

8- How is the fire detected? By personnel only or by instruments			
		By personnel	By instruments
Austria	A		1
Australia	AUS	1	1
Belgium	B		1
Brazil	BR		1
Canada	CDN		1
Switzerland	CH		1
Czechoslovakia	CS		1
France	F		1
Italy	I		1
Japan	J		1
Norway	N		1
Sweden	S		1
Great Britain	UK		1
Soviet Union	USSR	1	

2	13
---	----

Comments to the answers regarding the question: How is the fire detected by personnel only?			
		Com ment	Explanation
Austria	A	19)	19) With water as extinguishing media, only detection by personnel
Australia	AUS		
Belgium	B		
Brazil	BR		
Canada	CDN		
Switzerland	CH		
Czechoslovakia	CS		
France	F		
Italy	I		
Japan	J		
Norway	N		
Sweden	S		
Great Britain	UK		
Soviet Union	USSR		

8.1 -Comments to the answers regarding the question: By instruments and which ones?			
		Com-	Explanation

		ment	
Austria	A	17)	17) Temperature and smoke sensors = smoke detectors = probe
Australia	AUS	18)	18) Temperature and ionization detectors = ionic smoke detectors
Belgium	B	20)	20) Temperature detectors
Brazil	BR	17)+18)	
Canada	CDN	17)+18)	
Switzerland	CH	17)+20)	
Czechoslovakia	CS	20)	
France	F	17)	
Italy	I	17)	
Japan	J	17)	
Norway	N	17+20)	
Sweden	S	20)	
Great Britain	UK	17)	
Soviet Union	USSR		

Question: 9- Is the fire ext. released by an other device then heat or smoke detectors?

9- Is the fire ext. released by an other device then heat or smoke detectors?			
		Yes	No
Austria	A	1	
Austrália	AUS	1	
Belgium	B	1	
Brazil	BR	1	
Canada	CDN	1	
Switzerland	CH	1	
Czechoslovakia	CS		1
France	F	1	
Italy	I	1	
Japan	J		1
Norway	N		1
Sweden	S	1	
Great Britain	UK	1	2
Soviet Union	USSR		1

10	6
----	---

Open question: What device?

9.1 - Additional explanations to the question: What device?			
		Comment	Explanation
Austria	A	21)	21) Differential relay
Australia	AUS	21)	
Belgium	B	22)	22) Differential relay and stator ground fault relay
Brazil	BR	21)+22)	
Canada	CDN	23)	23) Differential relay and winding fault relay
Switzerland	CH	21)	
Czechoslovakia	CS		
France	F	22)	
Italy	I	22)	

Japan	J		
Norway	N		
Sweden	S	22)	
Great Britain	UK	23a)	23a) Electric protection relays
Soviet Union	USSR		

Question: 10- Do you specify procedure to prevent unnecessary release?

10- Do you specify procedure to prevent unnecessary release?			
		Yes	No
Austria	A		1
Australia	AUS	1	
Belgium	B		1
Brazil	BR	1	
Canada	CDN	1	
Switzerland	CH	1	
Czechoslovakia	CS		1
France	F		1
Italy	I		1
Japan	J	1	
Norway	N		1
Sweden	S	1	
Great Britain	UK	1	
Soviet Union	USSR		1

7	7
---	---

Open question: What procedure?

10.1 - Additional explanations to the question: What procedure?			
		Comment	Explanation
Austria	A		
Australia	AUS	24)	24) Interlocking with electrical protection relays
Belgium	B		
Brazil	BR	24)+23)	23) Differential relay and winding fault relay
Canada	CDN	24)	
Switzerland	CH	24)	
Czechoslovakia	CS		
France	F		
Italy	I		
Japan	J		
Norway	N		
Sweden	S		
Great Britain	UK	23a)+25)	23a) Electric protection relays 25) Release after visual confirmation
Soviet Union	USSR		

Question: 11 - Is the fire ext. released immediately?

11- Is the fire ext. released immediately?			
		Yes	No

Austria	A	1	
Australia	AUS	1	
Belgium	B	1	
Brazil	BR	1	
Canada	CDN		1
Switzerland	CH	1	
Czechoslovakia	CS		1
France	F	1	
Italy	I		1
Japan	J	1	
Norway	N	1	1
Sweden	S	1	
Great Britain	UK	1	1
Soviet Union	USSR	1	1

11	6
----	---

Open question: What step first?

11.1 - Additional explanations to the question: What step first?			
		Comment	Explanation
Austria	A		
Australia	AUS		
Belgium	B		
Brazil	BR		
Canada	CDN	27)	27) Trip unit and field breaker first
Switzerland	CH		
Czechoslovakia	CS	27)	
France	F		
Italy	I	27)	
Japan	J		
Norway	N	27)	
Sweden	S		
Great Britain	UK	27)	
Soviet Union	USSR	27)	

Question: 12 - Does the fire ext. also fight fire in the bearing?

12- Does the fire ext. also fight fire in the bearing?			
		Yes	No
Austria	A		1
Australia	AUS	1	
Belgium	B	1	
Brazil	BR	1	
Canada	CDN		1
Switzerland	CH	1	
Czechoslovakia	CS	1	
France	F	1	
Italy	I		1
Japan	J		1
Norway	N		1
Sweden	S		1
Great Britain	UK	1	

Soviet Union	USSR		1
--------------	------	--	---

7	7
---	---

Open question: And at what conditions?

12.1 - Additional explanations to the question: And at what conditions?			
		Com ment	Explanation
Austria	A		
Australia	AUS	28)	28) With CO2 as extinguishing media and bearings in the protected area
Belgium	B	28)	
Brazil	BR	28)	
Canada	CDN		
Switzerland	CH	28)	
Czechoslova kia	CS	28)	
France	F	28)	
Italy	I		
Japan	J		
Norway	N		
Sweden	S		
Great Britain	UK	28)	
Soviet Union	USS R		

Question: 13 - Do you specify provisions to remove fire ext. media?

13- Do you specify provisions to remove fire ext. media?			
		Yes	No
Austria	A	1	
Australia	AUS	1	
Belgium	B		1
Brazil	BR		1
Canada	CDN		1
Switzerland	CH	1	
Czechoslovakia	CS	1	
France	F	1	
Italy	I		1
Japan	J	1	
Norway	N		1
Sweden	S		1
Great Britain	UK	1	
Soviet Union	USSR		1

7	7
---	---

Complement question: What is the max. nr of machines protected by one storage?

13.1 What is the max. nr of machines protected by one storage?		
		Quantity:

Austria	A	2
Australia	AUS	2-4
Belgium	B	1
Brazil	BR	3-8
Canada	CDN	-
Switzerland	CH	1
Czechoslovakia	CS	4
France	F	1-2
Italy	I	2-3
Japan	J	1
Norway	N	1-4
Sweden	S	4
Great Britain	UK	1-3
Soviet Union	USSR	1

Question: 14 - Future trend for ext media?

14- Future trend for ext media?			
		Comment	Additional explanation
Austria	A	-	
Australia	AUS	29)+30)	29) Halon; 30) Water
Belgium	B	-	
Brazil	BR	-	
Canada	CDN	29)+30)	
Switzerland	CH	-	
Czechoslovakia	CS	-	
France	F	30)	
Italy	I	-	
Japan	J	29)+30)	
Norway	N	29)	
Sweden	S	29)	
Great Britain	UK	29)+30)	
Soviet Union	USSR	30)	

Complement question: 14.1- Future trend for fire detection?

14.1- Future trend for fire detection?			
		Comment	Additional explanation
Austria	A	-	
Australia	AUS	31)	31) Heat sensing cable (new temperature detectors)
Belgium	B	-	
Brazil	BR	32)	32) Ionic smoke detectors
Canada	CDN	32)	
Switzerland	CH	-	
Czechoslovakia	CS	-	
France	F	31)	
Italy	I	-	
Japan	J	32)	
Norway	N	32)	
Sweden	S	-	
Great Britain	UK	31)	
Soviet Union	USSR	-	

Question: 15 - Is there a need for international standard?

15- Is there a need for international standard?			
		Yes	No
Austria	A		1
Australia	AUS		1
Belgium	B		1
Brazil	BR	1	1
Canada	CDN	1	
Switzerland	CH	1	1
Czechoslovakia	CS		1
France	F		1
Italy	I		1
Japan	J		1
Norway	N	1	
Sweden	S		1
Great Britain	UK		1
Soviet Union	USSR	1	

Additional explanations:	
Comment	Additional explanation
33)	33) No standards but recommendations
33)+34)	34) Yes for CO2 gas cylinders (standardization)
33)	
33)	
33)	
33)	

5	11
---	----

End of Dr. Kranz's reformulated tables.