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Experience Gained and Lessons Learned During the BA3 Fire Repair and Cleanup May-July 1997

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Abstract

The paper presents an overview of the recovery from the fire which took place in BA3 on 13th May 1997. Brief outlines are given of the material damage sustained, the pollution encountered, and the cleaning processes employed. Repairs and cleaning of the building and equipment took over 2 months to complete at a cost in excess of 10 MCHF. The SPS physics program was interrupted for a period of 10 weeks and the LEP start-up was delayed for 6 weeks.

The experience gained by the co-ordination team is discussed and advice which may be useful for future reference is included.

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Contents

1 Introduction

A report has already been produced by W. Weingarten (TIS) [1] containing a technical description of the origin of the fire, together with the lessons to be learned from a personnel safety perspective. This paper will therefore not cover the details already treated therein, but will concentrate on the experience gained by the co-ordination team.

The repair and cleaning of the affected building spanned 8 weeks. In the order of 10 weeks of SPS physics were lost and around 6 weeks for LEP, including the subsequent start up.

No one was injured in any way by the fire.

A fact-finding commission was set up to investigate the causes of the fire comprising: J. Fivet (TIS), P.K. Frandsen (LHC) President, L. Stampfli (DSU), H. Wahl (SL). The findings of the committee were submitted to the Director General on 20th May 1997.

2 Location: BA3 (bat. 870), the heart of the SPS.

BA3 is a vast hall, 90 m long by 21 m wide and 8 m high, devoid of any separating walls and connected to the annex BB3 (65 m X 20 m) by a 30 m long passageway. The complex is completed by BAE3, which adds around 1000 m^2 on two levels. The total surface area is in excess of 4000 m^2. No doors of any kind separate BA3 from the annexes. Detailed layout drawings of BA3/BAE3, and BB3 are available as: SPS EY 3001 0 and SPS EY 3000 0 respectively.

So much equipment fundamental to the functioning of the SPS is contained within this building complex, that it can rightly be called the heart of the machine. The following list is by no means complete, but gives an idea of the building's importance:

- Power Converters
  - All main quadrupoles plus spare.
  - Sextant 3 main dipoles.
  - Chromaticity sextupoles.
  - Landau damping octupoles.
  - Skew quadrupoles.
  - Sextant 3 orbit correction dipoles.
- Radio Frequency
  - Power converters and transmitters for 200MHz travelling wave proton acceleration system.
  - Power converters and transmitters for 200MHz standing wave lepton acceleration system.
  - Low level and interlock electronics for the above systems.
- Electrical Distribution
  - Electrical cells for 18 kV stable and pulsed Loops.
  - No-Break power supplies for local equipment.
  - 48V cells for control, alarms, etc.
  - Auxiliary compensator.
- Other Equipment
  - H.V. Supplies for vacuum pumps and electronics for sector valves and pressure gauges of sextant 3.
  - Beam position monitors for sextant 3.
  - Timing electronics.
  - Controls network racks.
  - Cooling plant for above mentioned power converters and associated magnets.

A malfunction in any of these systems is sufficient to stop the SPS. The LEP machine is also affected since its beam is supplied by the SPS. The complexity of the building is compounded by the fact that all cables pass under a false floor, which covers 90% of the total surface.

3 Description of Incident

At around 06:30 on the 13th May 1997 (see [2] for precise timing) a fire occurred in one of four 1 MW power converters that supply the 200 MHz proton acceleration RF system located in BA3. PCR personnel saw smoke in BA3 and called the fire brigade, whose response was very rapid as they were already on the Prévessin site. The fire was extinguished during a 20-minute intervention. Direct material damage at first sight appeared to be limited within the power converter cabinet and vertically above. More worrying was the fact that the whole building was filled with thick black smoke. A detailed technical description of the causes of the fire is contained in [1]

Following standard procedure, the fire brigade contacted the chemists of TIS-GS who in turn, after investigation, made contact with the specialist company Reichenberger AG (RAG) [3]. Other people informed included the Director General, the Director of Accelerators, TIS and SL Division Leaders, the SL Crisis Co-ordinator, the Legal Service and the insurance company Mobiliére Suisse. This rapidity of reaction turned out to be crucial to setting up the recovery process.

As soon as the fire was extinguished, and in parallel with the actions above, the firemen began to evacuate the smoke by opening all doors and installing smoke extractors. Once the initial smoke cloud had dissipated sufficiently, drying and heating equipment was installed by RAG to reduce the levels of humidity (heavy rain fell throughout the intervention period). The doors were closed and access to the buildings was prohibited during the drying process. At the request of the RAG specialists the normal ventilation system was not used for drying as the resulting turbulence would have further distributed soot throughout the equipment.

4 Material Damage

The 1 MW power converter, which was the seat of the fire, was completely destroyed and had to be replaced, but on the horizontal plane the fire was well contained within its steel cabinet. An electrical distribution rack in very close proximity and several adjacent false floorboards, were however damaged by the heat and also had to be replaced. The paint of several nearby racks was blackened, but it was possible for these to be cleaned and repainted, their contents being undamaged.

More damage was sustained vertically above the fire due to rising heat and the action of the ventilation system. Unfortunately the overhead crane had been parked immediately above the power converter and therefore sustained considerable heating necessitating its replacement. The power rails for the crane had completely melted over a length of 3 m. Nearby cables and lighting were also extensively burned,and many of the fluorescent tubes had exploded. Due to the fact that the cost of cleaning was greater than the price of replacement, all cable trays and overhead lighting (including emergency lights) were renewed.

It was immediately evident that the steel of the roof had suffered, the extent of which was revealed when samples of the steel/insulation/waterproofing sandwich were later analysed, with the result that 200 m^2 of roof were replaced.

5 Pollution: Acid, heavy-metals.

It was clearly apparent that all surfaces inside the building were covered with black soot. All the equipment in the hall of BA3 was affected, as were the walls, floor and ceiling of the building. Due to the effect of the ventilation system, all racks were polluted inside their enclosing cabinets, and of course the labyrinthine area beneath the false-floor with its congestion of cables and pipes was just as badly affected. Within the hall, the Faraday cage containing RF low level electronics, and the computer room were apparently also affected but to a slightly lesser extent. The same was true for BB3.

Since the installation which had been burnt was in the order of 25 years old, the major immediate worry was that the smoke contained chloric acid produced by the burning of PVC insulated cables. The soot, which was observed to be present even inside racks and on electronic cards, was electrically conducting and would produce short-circuits if not removed.

The burned power converter contained 2 mercury-based ignitrons, only one of which, whose container was split, was to be found in the debris. The ignitrons contained a total of 94 cc of mercury, a certain amount of which remained inside the broken container and more was found mixed with water (condensation) in the cabinet tray. Exact measurements of the amount of remaining mercury were impossible, but around 80 cc were estimated to be missing, vapourised.

6 Analyses: What to clean & method to be employed.

To a large extent it was very obvious which parts of the building and its infrastructure needed to be replaced or cleaned, and RAG was well aware of the prescribed method. A certain amount of obvious work could therefore be undertaken in parallel with the taking of samples and before receiving the results of the analyses.

The analyses served two distinct though associated purposes. Firstly they established the conditions under which the work would be carried out from the Safety/Hygiene point of view, and secondly, the level of equipment cleaning necessary and hence the method to be employed.

The independent Swiss institute Eidgenössische Material-Prüfungs und Forschungs-Anstalt (l'EMPA) of Dübendorf, was called in to take samples for analysis from all affected areas [4]. Analyses of the air of the building were made by the Institut Universitaire Romand de Santé au Travail (IST) de Lausanne and also Service de l'Ecotoxicologue Cantonal de la République et Canton de Genève (Ecotox) together with the CERN chemists. Traces of mercury were indeed found. Evidence of lead and cadmium pollution, were also detected, the levels of which were far below the limiting values published by the Swiss Caisse Nationale d'Assurance (SUVA).

No trace of heavy metals was found beyond the confines of BA3.

6.1 Personnel (health and safety)

Results of the EMPA analyses showed that the major pollution from heavy metals was concentrated as particles on the ceiling of the hall, in the ventilation filters and in the fibre glass insulation of the building walls. The decision was taken by the CERN Chemists and Medical Service to impose the wearing of full protective overalls, as well as filter nose/mouth masks for all who entered the BA3 complex. Those RAG personnel who worked on cleaning the ceiling wore full-face masks. Once the ceiling was clean, further analyses of the air were taken, and work was allowed to continue without the masks, except for those employed upon removal of the wall fibreglass and the ventilation system where a certain amount of dust disturbance was inherent in the process.

In view of the presence of heavy metals, the CERN Medical Service organised systematic medical visits (haematology & urology) for everyone working in the buildings in question, whether CERN, contractor or from an outside company. In the order of 150 people were controlled and no evidence was found in anyone of heavy metal contamination due to exposure in BA3[5].

6.2 Equipment

As l'EMPA processed each set of analyses, the results were faxed to RAG and CERN at the BA3 site to allow work to progress on several fronts without waiting for the final report. Due to the extent of the pollution and the complexity of the equipment and building, several visits were needed to complete sample gathering. Results concerning mercury pollution were inherently long (4 days), whereas acid levels were received 1 day after sample taking. A full report of all of the results is available for consultation from the authors or a copy can be ordered directly from l'EMPA, but is not annexed herewith in view of its bulk [4].

Soot on building and equipment surfaces had to be removed to prevent it eventually finding its way into the electronic components under the influence of the ventilation system with the risk of causing short-circuits. Where analysis showed only soot to be present, the degree of pollution was simply determined visually. Since there are no recognised reference limits for soot pollution, the method and degree of cleaning was largely decided by RAG for each piece of equipment, based upon previous experience.

In order to eliminate the risk of corrosion due to hydrochloric acid attack, it was necessary to clean all building and external cabinet surfaces where the acid concentration was above 15 $\mu g/cm^2$. All exposed surfaces of BA3, BB3 & BAE3 including floor, walls, ceiling, beneath the false-floor and all cabinet and equipment surfaces needed to be most thoroughly cleaned. Electronic and electric components with less than 5 $\mu g/cm^2$ of pollution were not cleaned, and anything over 10 $\mu g/cm^2$ required thorough cleaning by immersion. All of the components situated in the main BA3 and BAE3 halls were found to be heavily polluted with acid and soot.

7 Cleaning Process

Priority was given to the ceiling of BA3, the cleaning of which, it was feared, would further pollute the equipment beneath with dust containing soot, acid and heavy metals. A load-bearing false ceiling was hung from the rafters, 2 m below the roof of BA3, covering the entire surface of the building. This installation made possible cleaning work on the ceiling, protected people and equipment beneath from dust and falling objects, allowed cleaning above and below to progress in parallel and provided protection during removal of the burned roof section. Later it also facilitated the replacement of the cabling and lighting installations mentioned above.

Firstly, vacuum cleaners with special cooled filters were used on all surfaces followed by humid cleaning with proprietary RAG cleansing and neutralising detergents. Special attention was paid to the floor and ceiling. Electronic components situated in the main BA3 hall which were heavily polluted with acid and soot, were removed wholesale from their racks, immersed in cleaning and neutralising baths, subsequently dried in vacuum ovens, and stored until the building was clean enough for re-installation. Faraday Cage modules, which were thankfully affected only by soot, were cleaned dry in situ by arranging air to be blown in above and sucked into vacuum cleaners below. BB3 and most of its equipment were also only superficially dry cleaned.

Great care was taken to assure that all the cleaning fluids used were recuperated and disposed of in the manner prescribed by the chemists of TIS-GS. No pollution of the drainage system was detected.

Porous materials such as the fibreglass matting wall insulation and the acoustic insulation around the cooling pump zone were unable to be cleaned and had simply to be replaced.

The greatest cleaning problems were posed by electrical distribution cells and no-break power supplies, especially in their H.T. and mechanical parts. Since a complete strip-down of these devices was necessary, and in view of their age and complexity, it was felt to be prudent to involve the manufactures of the apparatus in the cleaning process. In some instances, high-tension specialists needed to readjust cables and connectors after re-installation by RAG. Despite all efforts, two of the older no-break power supplies were unusable after cleaning and had to be replaced.

8 Organisation of Effort

In view of the scale of the BA3 repair and clean up, it turned out to be essential for a co-ordination team of two people to take overall responsibility for the work. Apart from organising the effort from the CERN side, and installing necessary infrastructure at the scene of the work, their role was to interface with the outside firms (mainly RAG) together with the insurance companies, chemists, medical service, press office and legal service. It was also their role to organise regular information meetings and ensure that status bulletins were issued.

First predictions from RAG, based solely upon professional experience, suggested that their work would take in the order of 2 months. Once the co-ordination team understood the scale of the operation, an information meeting was called including RAG, the Insurance Company and its experts and from CERN the SL Division Leader, the Director of Acclerators, the TIS chemists and Doctors, and specialists of the equipment involved. The main aim of the meeting was to make everyone aware of the scale of the repair, and to allow RAG to explain the method of work. Ground-rules were set for the coming weeks, such as:

- Priorities to be set by the co-ordinators.
- Only the co-ordinators were to interface between CERN and RAG to avoid conflict of interests.
- CERN services were made aware of the exceptional urgency of the situation.
- CERN specialist presence in BA3 was to be only by invitation of the co-ordinators.
- A specialist was to be named for each set of equipment.
- Regular weekly meetings were to be held between RAG and CERN specialists.
- Weekly meetings with the Insurance Company and its experts were also organised.

As the electrical distribution system was polluted, temporary supplies were necessary and a representative of the power distribution service was nominated to take overall responsibility for electricity and to assure a permanent presence during the work.

As the work later progressed it became increasingly evident that certain of the decisions taken at the first meeting were of vital importance, other measures were later instigated as their need was felt.

So many demands were received from the owners of the equipment that without the co-ordinators, RAG would quickly have become submerged in conflicting requests. The temporary electrical supply situation became rapidly extremely complex and the permanent presence of a team of electricians was necessary under the leadership of a technician not only highly competent technically, but also very conscious of the safety considerations involved. A security linkman was nominated by TIS-GS to help with the personnel safety of the hundred or so people involved at any given time.

Communication proved to be a most difficult area to deal with. Despite the fact that many different media were employed (information meetings, E-mail, WWW, weekly bulletin, SPS page1 & LEP page101, etc.) there were areas where important messages just did not get through. In a future crisis of this magnitude, the importance of information communication should be emphasised.

The SL division DPO was made responsible for all financial aspects, a special budget code was quickly made available greatly facilitating equipment and service commands. Close contact was maintained with the insurance experts, whose rapid acceptance of expenditure was also instrumental in minimising overall duration.

9 Planning

Since CERN lacked experience of this type of situation, and despite the reassurance of the insurance experts, there was an uneasy feeling of total dependence upon RAG, both technically and as far as time estimates were concerned. Help from the planning department (AC-DI) was instrumental in demonstrating that given close collaboration, and by working day and night shifts, a saving of two weeks on the original time estimate was possible. The planning charts provided a focal point for discussion, and the visual representation of the way in which the work advanced was a boon to everyone involved. Using the charts, the importance of the time factor was more easily stressed, and a greater portion of the control passed to CERN, reducing the dependency upon RAG.

10 Safety Considerations

The Weingarten report [1] deals fully with the safety aspects of the BA3 work, but for the sake of completeness, and in order to reinforce a most important message, it is useful to make certain reminders herein.

Once the problems of pollution and associated personnel protection were dealt with, by far the most potentially hazardous area was the temporary electrical distribution installation. Sterling work was carried out by the electrical service, not only with regard to general safety of temporary installations but also in ensuring the electrical safety of all installations during the cleaning process and later during the testing phase. Before a particular piece of equipment was made available to RAG for cleaning, both the owner and the electricity service established an 'Autorisation de Travail' form declaring that it was electrically safe. Once the cleaning was finished, the corresponding 'Fin de Travail' form was completed by RAG to indicate that they would make no further interventions.

It was virtually impossible to stay abreast of the problem of open floorboards. Especially during the period of cleaning under the false floor, it became a full time job for CERN and the RAG foremen to keep up with the advancing work. Thanks to the deployment of tapes, chains and barriers to indicate missing boards, no one was injured by falling into holes in the floor (statistically the most frequent accident at CERN).

One person was however injured when he fell from the false ceiling during its removal. It was surprising that more accidents did not take place during this particular operation, the work force of the sub-contractor in question was obviously determined to finish the job within the day, not wanting to incur the expense of a stay-over. Despite several safety-related improvements imposed by CERN personnel, the situation remained typical of a job being carried out by people brought in a long way from home, and given a price for the completion of the work rather than an hourly rate. Such a situation must be avoided in future, crisis or no crisis.

Another area of potential danger was the car park and access roads to the affected buildings. These zones were variously taken over for temporary office space, temporary toilets, open-air workshops, storage areas, and rubbish containers. Limited parking was assured, but more importantly access for the fire brigade was always maintained and whenever necessary lorries, cranes and containers were able to safely come and go. The area became much more heavily populated than usual, but since the Service De Guardienage took the traffic problem seriously from the outset, very few problems were encountered. The same service also oversaw personnel access to BA3 while the normal access system with card readers was out of action. One slight accident did occur when an appliance fell from a delivery truck slightly injuring the driver as he released the securing belts.

11 Post Mortem

Once the work in BA3 was finished, and equipment tests had shown that the SPS was in a state to fulfil its normal role, a final co-ordination meeting was organised with a view to collating the views of the different services involved in the repair. All the equipment and safety groups were invited, together with the CERN doctors, chemists, firemen and the legal service. Rrepresentatives of RAG and the insurance experts were also invited. Comments and criticism of all kinds, both positive and negative, relative to the fire and recovery were freely encouraged, the aim being to produce a list of 'DOs' and 'DON'Ts' which could serve as a check-list in a possible future incident of a similar nature.

Remarks issuing from the post mortem are included in the following section, which also contains ideas and improvements that manifested themselves during the recovery period.

12 Lessons & Conclusions

The following points are not considered to be in any particular order of importance. There is a certain chronology to the ordering however, which may be beneficial if this section is to serve as a checklist in future.

- **Rapid intervention essential.** Signs of hydrochloric acid corrosion were clearly visible only two days after the fire.
- **Co-ordination Team Vital.** It is vital to establish a co-ordination team immediately. In the case of the BA3 incident, two co-ordinators took care of the technical and infrastructure work, an electricity technician oversaw the global situation of electricity supply and the SL division DPO dealt with finances. With hindsight, the team would have been improved by the addition of a further person to handle communication (E-mail, WWW, SLNEWS, Teletext, etc.).
- **No work to start until risks assessed (pollution).**
- **No Compromise on Safety.** A safety linkman was necessary for work on this scale.
- **Communication / Information Vital.** This area could have been better dealt with. One LEP experiment was almost late for start-up due to lack of information. NOT TO BE UNDERESTIMATED.
- **Close contact with insurance, quick response necessary.** A good working relationship with, and quick response from, the insurance experts was instrumental in keeping time to a minimum.
- **Quick response from CERN services.** Speed of intervention by the various CERN services involved was of primary importance in minimising the overall duration. Whether it was the legal or transport service, the doctors or the firemen, it was vital that they were aware of the urgency of the situation from the outset.
- **Infrastructure necessary (toilets, tel. fax. PC. parking, soft drinks machine etc.)** Many of the necessary services were available close by in PCR. Had this not been the case it would have been necessary to install them. RAG understood this problem very well and immediately installed offices, stores and workshops and requested telephone, fax and network connections. Temporary toilets and showers were set up adjacent to the work site in accordance with French Sécurité de Travail regulations. The 500 m^2 tent which served as the electronics cleaning workshop saved an incalculable amount of time, without it components would have had to be shipped to RAG H.Q. for cleaning.
- **All samples of pollution to be taken early.** All samples were taken in time, but there were a few surprises in the later batches.
- **Close collaboration between CERN specialist and RAG.** It would be a mistake to naively allow cleaning of equipment, without contact with the specialist. The (few) problems encountered with the RAG work all involved equipment where the specialist was less present.
- **Electricity Overseer ——key man.** The BA3 situation rapidly became very complex, the chief electrician needed to be competent, responsible and safety-conscious.
- **Document for future reference...(reports, minutes, photos, videos).** Another area not to be underestimated. Again RAG understood this issue very well.
- **Co-ordinators must retain responsibility. No one else must plan.** They are the only people with a wide enough overview.
- **Biggest Co-ordination Problem...non-availability of CERN Staff.** Despite E-mail, mobile telephones etc. an inordinate amount of time was spent in trying to locate CERN staff responsible for different activities when immediate decisions were to be made.

13 Post Scriptum

The quality of the BA3 recovery work was proven by the speed of the subsequent start-up and the efficiency with which the SPS ran during the ensuing physics period. The overall efficiency figure of 80% of realised hours with respect to programmed hours was the same both before and after the fire. However, statistics show that in the 2 months following the clean up, there were more short (under 1hr) interventions on the BA3 RF equipment compared with before the fire. The global RF downtime has not increased significantly, but the number of short stops rose from roughly 6 or 7 per month prior to the fire, to between 20 and 30 per month since.

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