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FIRE PROTECTION SYSTEM IN THE ECN HOT CELL LABORATORY

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1. INTRODUCTION

A fire protection system in a Hot Cell Laboratory is just as important as the radiation and contamination protection systems. With respect to radiation and contamination protection we all experience daily practice and have done so for many years. The knowledge on detection and fighting of an in-cell fire, is -as consequence of good prevention measurements- much more limited.

The choice of an adequate system in the hot cells is to a large extend based on "cold" experience, in combination with theoretical and practical considerations and assumptions.

This document gives a description of the ECN-HCL approach towards (of) the in-cell fire problem to different fire dectection and fire extinguishing equipment installed in or near the hot cells. The entire system is recently being subjected to a critical analysis, which will lead to some essential modifications. In that sense this document has to be considered as a working document, which is "open for discussion".

2. FIRE PREVENTION

Fire protection in its most simple form is the absence of burnable material. For this reason a set of rules exists for limiting the presence of such materials in the hot cells as much as possible, in combination with operational requirements.

If inflammable material has to be used, burnable material such as tissues etcetera is removed beforehand. The presence of at least two operators is required under such conditions. A potential cause of fire ignition is an electric short-cut. For that reason all power supplies are cut off from the hot cells outside working hours.

3. FIRE DECTECTION

The in-cell conditions are special in terms of a high irradiation level and a continuous flow of air from the intake to the outlet filters. The first factor sets the demands for radiation-resistant components etcetera. Because of the second factor, the air-stream, the choice for the location of the detector in the cell is essential. This implies that the usual location of a fire detector -at the ceiling- is not necessarily the best in a hot cell.

HA-cells

In our HA-cells, figure 1, we have chosen for a heat detection system. In each of the high activity concrete cells a thermo differential detector, made by Siemens, type D9.00, has been mounted. This type of heat detector will trigger if the local temperature reaches 57 °C and/or if the temperature increases more rapidly than 10 °C per minute. In figure 2 the locations of the air intake, the air outlet and the heat detector in the HA-concrete cells are indicated schematically. The heat detectors are situated above the cell window, approximately 130 cm above the cell table surface. The detectors are mounted on a stainless steel wall plug.

Metallographic and chemical cells

The metallographic and chemical cells are constructed of lead blocks with stainless steel, air tight inner boxes.

If a fire is detected trough one of the above mentioned systems, the signal will become visible at the laboratories central control board and at the same time trigger the acoustic alarm. In addition the fine warning signal is automatically transmitted to the central ECN control room and to the companies fire brigade.

4. FIRE EXTINGHUISING SYSTEMS

4.1. The HA-concrete cells

Untill recently the concrete cells were equipped with one central B(Broom) C(Chloor) F(Fluor)-system (Halon 1211). It consists of a central BCF-storage tank with supply tubes to each of the five concrete cells. Activation of the system is not automatically, but through one of the (glass protected) buttons, located next to each cell window.

The original system is constructed in such a way that, once it is activated, BCF is injected in all five cells at the same time. Recent calculations however, have indicated that this might lead to serious damage and malfunctioning of the exhaust ventilators, because of the higher specific weight of BCF compared to air. For this reason the system has been re-designed in such a way that BCF will be injected only in that cell where the fire occurs. This has also the advantage that the disturbance of the other cells is avoided or at least limited. Modification of the BCF-system according to this principle will be carried out in the course of 1990.

Even under the new circumstances the wish exists to limit the use of BCF to those conditions where it is absolutely necessary. Or, in other words, for small to medium cell fires we would prefer, as a first choice, a system that is capable of extinghuising it and at the same time causes less disturbance of the cell. For that reason all individual cells will be equipped with medium size CO_2 extinguishers. Installation is planned for the second half of 1990. One of the HA-concrete cells, which is used amongst others for special dismantling work when e.g. sodium is involved, has from the start of its operation (1964) been equipped with such a CO_2-system. During the past 25 years the system has a few times proved to be adequate for extinguishing small fires.

4.2. The metallographic and chemical cells

The α-tight metallographic and chemical cells are equipped with a nitrogen-flushing system with central supply tank. The purpose is twofold. In the first place the cells can be flushed with N_2 to minimize the oxygen and/or moisture concentration in the cells, if so required from operational point of view (e.g. fire protection or to avoid moisture uptake by samples). Furthermore this N_2-flushing capability serves as primary fire extinghuishing system. In addition certain cells are equipped with their own BCF-extinghuisher.

4.3. The Pb-cells for mechanical testing

The Pb-cells for mechanical testing contain only metal radioactive materials with a very low contamination level. So far these cells are not equipped with their own specific fire extinguishing system.

5. LISCENCING RELATED ASPECTS

In the introduction it was stated that a HCL's radiation protection and fire protection system are of similar importance. This is true from a normal operational point of view. When liscencing comes into the picture, the fire protection system (prevention & fighting) is no doubt of prime importance, because this determines the possible dimensions of the source term and ultimately the public risk. It is the latter that counts primarily for liscencing authorities.

This last point often forces us to analyse an already satisfying fire protection system in search of modifications that, on the basis of theoretical analysis, might reduce the public risk as much as possible. Fire protection in this broader sense will then rely, amongst others, on the following points:

- fire prevention (i.e. absence of inflammable materials, cut off power supply outside working hours, etcetera).
- fire extinghuising systems → redundancy.

- minimizing the source term through:
  - minimizing amount of radioactive materials in the cells
  - protecting fuel rods or elements (e.g. in-cell storage in stainless steel tubes).

All of the precautions indicated above, should or could be taken, if to a reasonable extend complying with requirements in terms of operation and exploitation. In that respect it is also reasonable to ask ourself the question: "What is the real risk of an in-cell fire and is perhaps the existing set of measurements already sufficient to limit the consequences to acceptable levels?". A discussion of this nature is certainly beyond the scope of this document and is, in fact, part of the (re)liscencing process. We would like to give however, one practical example:

An essential point in judging in-cell fire consequence is the maximum temperature that will occur. We take as an example a fire, fed by cell-window oil leaking into the cell (circa 70 dm^3). Data from the literature on such fires indicate a maximum temperature of 700 °C. This was confirmed by a test we performed through burning typical cell-window oil in a large drum, equipped with thermocouples at various heights above the oil level (see figure 3). The observed temperatures at the different positions, are shown in figure 4 as a function of time, indicating a maximum temperature stabilizing at ~ 700 °C. The value of 700 °C implies that Zr or stainless steel fuel rod cladding will remain intact during such a fire. Of course the relevance of the test for in-cell conditions can be subject for discussion and improvements are possible. The point that we would like to illustrate is that "being in control off" means not only the use of a good fire protection system but also knowledge about the consequences, which should neither be underestimated nor overestimated wildly.

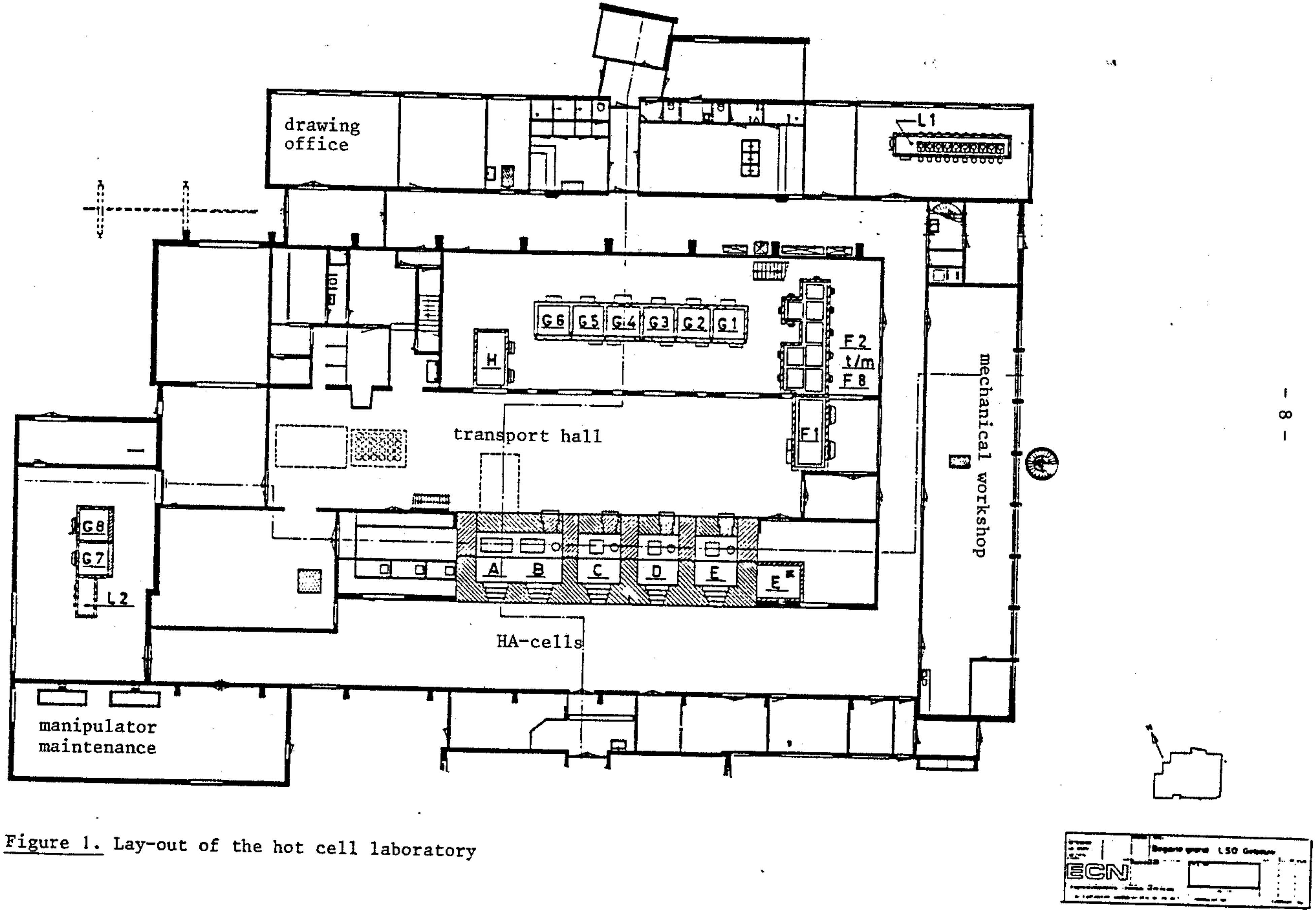

Figure 1. Lay-out of the hot cell laboratory

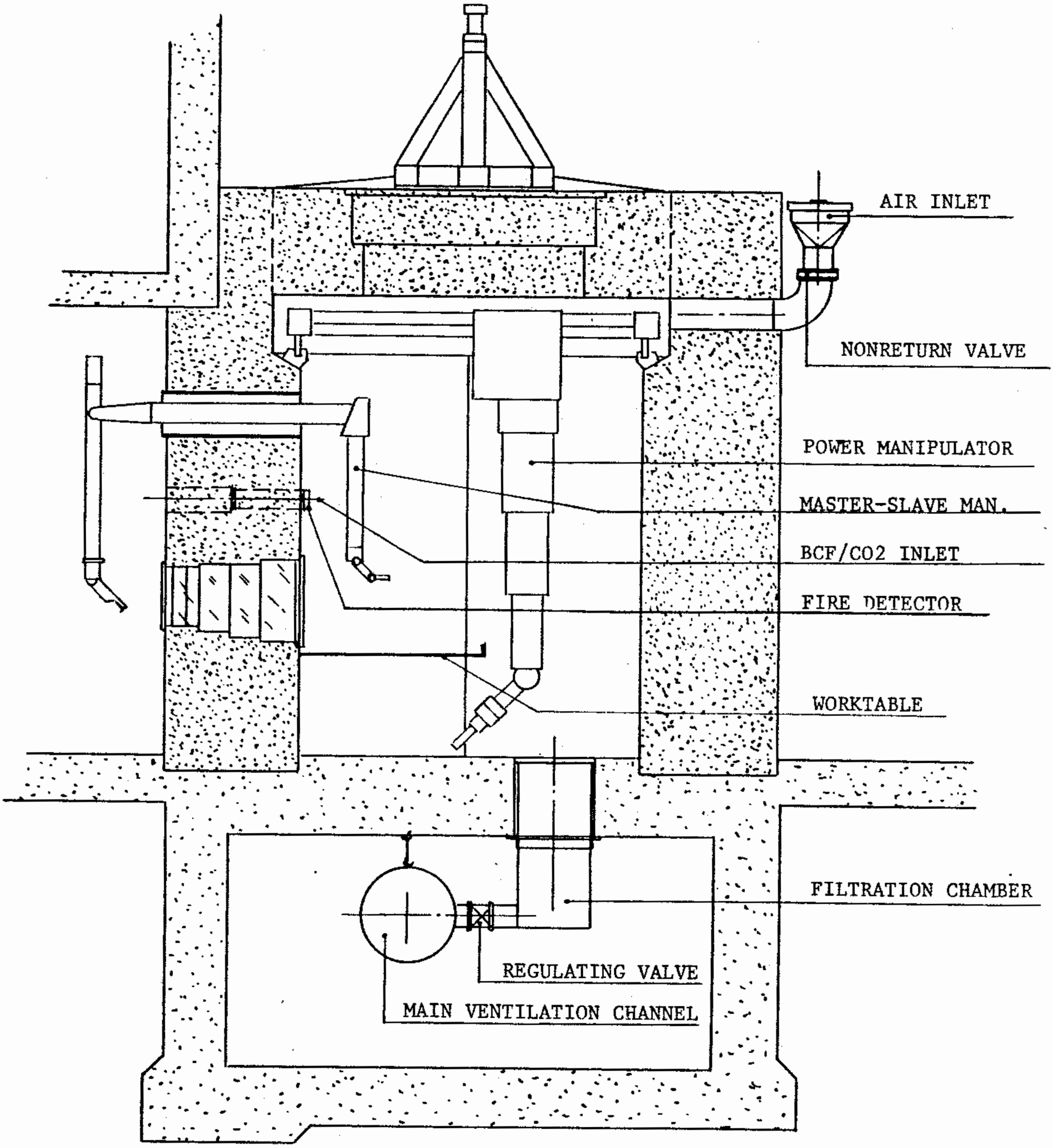

Figure 2. Cross section of concrete cell

1m. SCALE 1:50

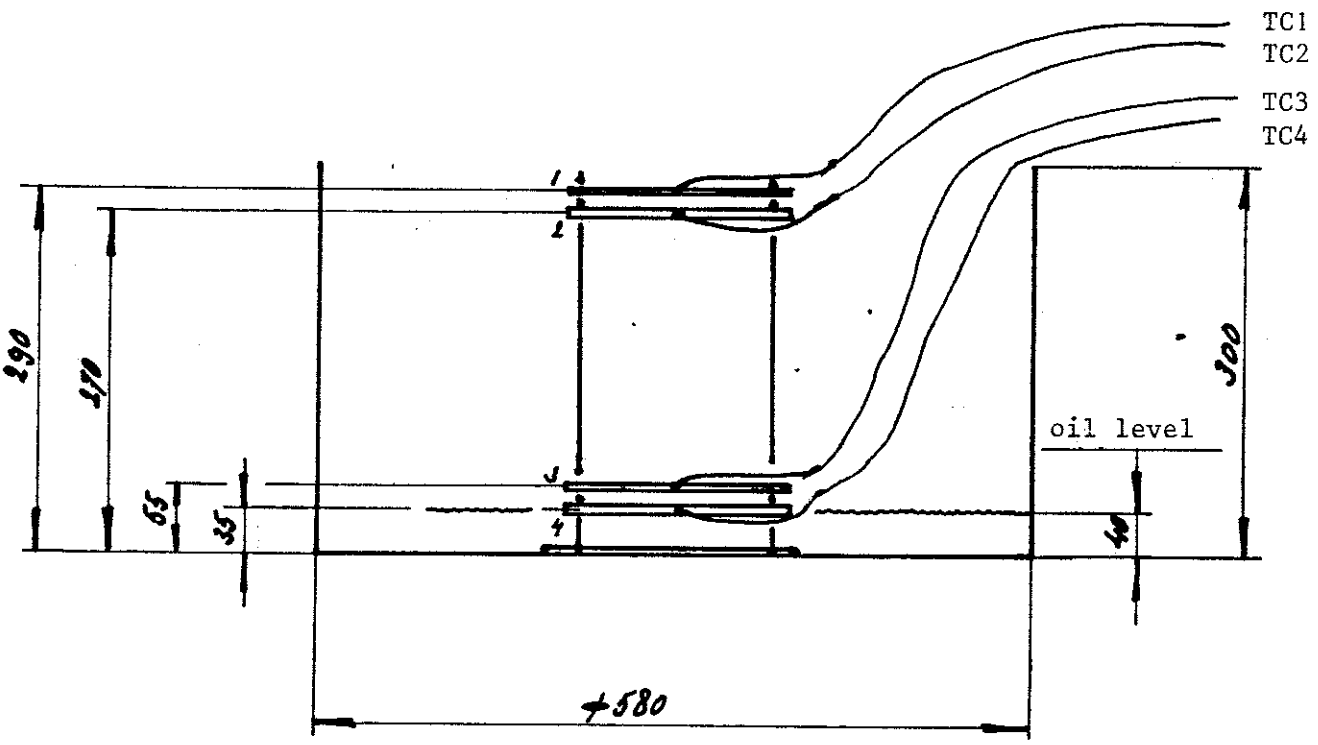

Figure 3. Schematic of the test set-up

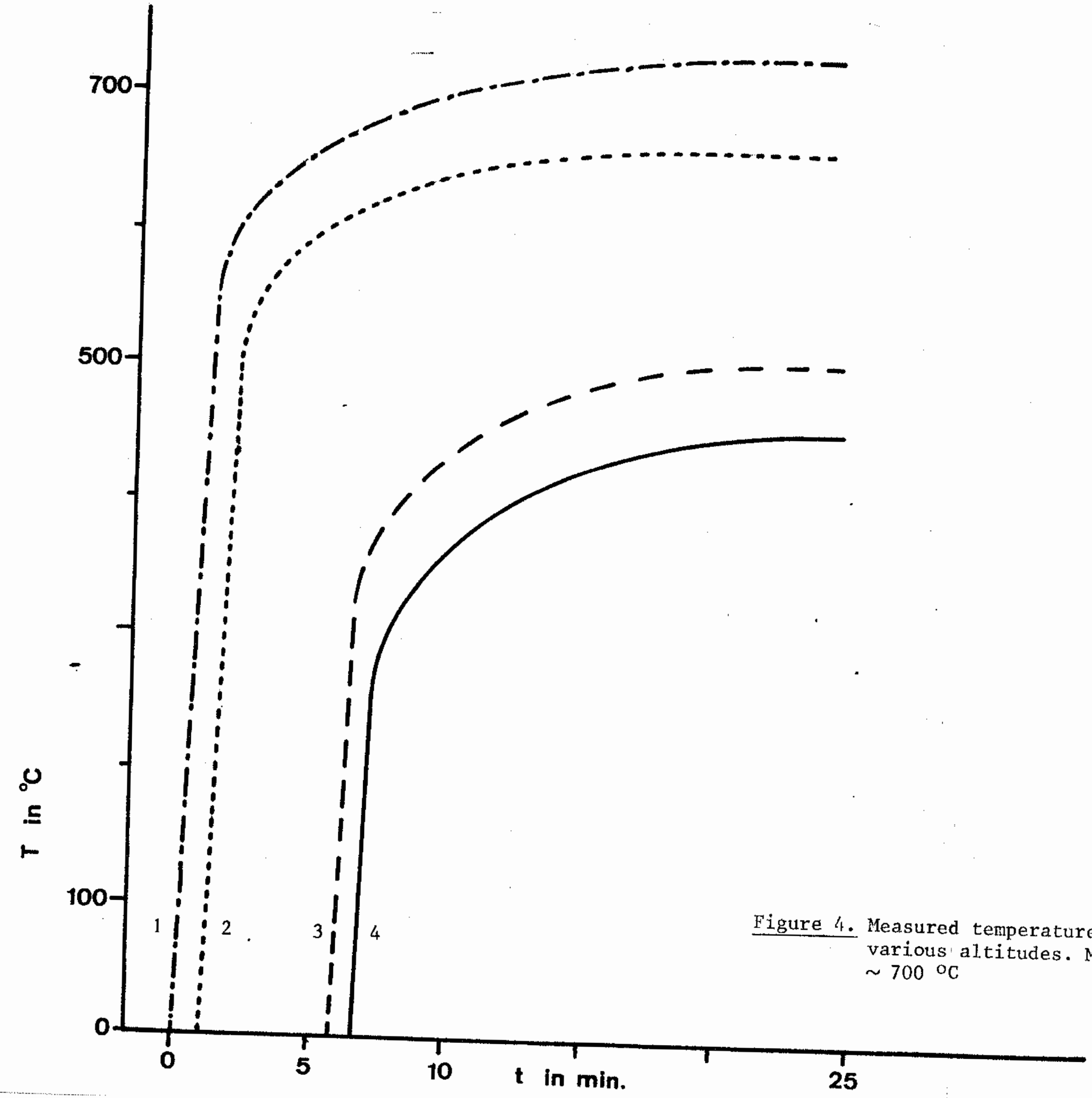

Figure 4. Measured temperatures in an oil fire at various altitudes. Maximum temperature ~ 700 °C