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Fire and Burglary Resistance Evaluation of Safety and Security Equipment — A Step towards Quality Control*

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Since the turn of this century, the volume of public records and business documents have increased rapidly. These records essentially should be housed properly. The annual fire loss to valuable property in our country is about ten billion rupees. However, a very small percent of the total number of fires in manufacturing plants, business and trade centres, banks and public buildings account for about 66.6 percent, of the annual fire loss. Some of the fires quoted in international literature remind us that valuable records, unless properly protected, can be destroyed even in fire resistant buildings.

The importance of availability of the documents have prompted (through competition) the manufacturer, for the development of quality record containers, especially of lighter weight with greater capacity and fire resistance. Heavy safes with improvements are used for keeping cash and valuables and so more attention has been paid to the burglary resistance. A part of the record containers, where fire resistance is the prime need, the safes have been largely replaced by modern fire resistive containers. Newer techniques of record keeping, that is, microfilms, electronic computer data tapes/discs area creating more challenging task for those in this field.

Construction Background

Although boxes provided with locks or coffers must have followed closely on the development of locks and had been used in ancient times in Egypt, yet there is no example earlier than the middle age. The boxes made at that time were of hard wood, strengthened and decorated with metals and subsequent developments took place on boxes entirely of metal rather on artistic boxes. On the continent of Europe the iron boxes were developed to a very high standard of artistic beauty and craftsmanship but with no real increase of security. Several of these artistic coffers supposed to be of 17th Century workmanship are preserved in the museum of Marlborough House. Up to the end of 18th Century, no attempt had been made to make coffers 'fire resistant', though in 1801, a patent for fire proofing had been taken by Richard Scott, but it does not appear to have been used. In the year 1834, a patent was taken by William Marr for the application of non-conducting linings, followed by a similar patent in the name of Charles Chubb four years later. However, the foundation of the modern safe/record containers industry was laid by Thomas Milner, originally a tinsmith of Sheffield (UK), who after a few years' business in Manchester, established his works at Liverpool in 1830 for the manufacture of plate and sheet iron boxes and later made plate iron chests or coffers and probably developed the earliest safes about the year 1846.

The development of securing the door by a number of shooting bolts operated by a handle and fastening them in the locked position by the lock-proper, in order that a key might be used, came though Charles Chubb's patent in 1845. In the year 1860 a patent was taken by Samual Chatwood for safe/record containers constructed of an inner and outer body with the intervening space filled with ferro manganese or spiegeleisen in a molten state, the total thickness being 51 mm. After this period, work started in two directions:

— For fire resisting record containers, the materials of high insulation value were developed and also the techniques of filling insulations into the intervening space. Fire and corrosion resistant coatings were also developed. The door edges were designed to restrict the flow of hot gases from the fire zone to the inside of the record containers by checking warping of door edges mechanically or with the help of gaskets of fire resisting materials, such as asbestos; and

— For burglary resistant containers, alloys with power of resisting the cutting effects of the gas flame were developed. To prevent insertion of crow bars attempts, door designs were perfected. To prevent penetration of heat and insertion of explosives through key holes, devices were developed which automatically closed the key hole as keys were taken out. Combination locks are also used in addition to key locks in burglary resistant containers. For extra safety 'time locks' with two, three or four chronometer movements are frequently employed in developed countries to control the timing for opening. These prevent the door to be opened at any other than the office time.

The record containers manufactured in the country are mostly double walled with mild steel body construction having the gap in between, filled in with fire resisting compositions such as foamed concrete mixed with moisture retaining mineral powders and inorganic binders with fibrous inorganic matter. After pressing and welding when the steel cage of the container is formed, painting of all the surfaces of the metallic cavity is performed with suitable paints. Then the intervening space is filled with insulating composition. There are three methods in general, of filling the space in between which are commonly employed:

— Insulating composition is filled through the back side of the record container. After necessary drying and curing of the insulating composition the back side is covered by sliding the sheet into the grove and some times tack welding is also done;

— The slurry of the insulating composition is introduced into the intervening space through a hole in the bottom of the container. When this injected slurry comes out from the other hole at the top side of the container, the bottom hole is plugged and for curing and drying of the composition some small holes are drilled inside walls of the container which are plugged by

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rivettes or stickers prior to painting of the outer surface; and

— The filling of the intervening space with precast insulating slabs is also carried out. In this technique back sheeting is provided in the same way as described above.

Requirements

The functional requirements of a record and currency protection container as per various national and international standards may be briefly summarized as follows:

— For fire resisting record containers the body must be constructed of steel sheets of sufficient thickness, this varied with the dimensions of the record container to withstand the effects of a fall from an upper floor in the event of fire and to resist the crushing effect of falling masonary, displaced girders, concrete beams, etc, as these heavy containers can get burried by falling debris in the ruins of a fire damaged building. The crucial evaluation of fire endurance/fire resisting capability of a record protection equipment is fully applicable under these conditions, that is, when burried under red hot mass of ruins, often for a period of several days, before it could be dug out and removed from the collapsed building. It should bear a sudden exposure to high temperatures without exploding. This situation may arise when a floor over a burning encloser suddenly collapses. The fire proofing composition packed around the whole area of body and door of the record protection devices must be of sufficient insulating value, to preserve the heat resistance capacity over a long period, otherwise, when the reserve insulating value will be exhausted the equipment would become a slow oven and its contents will get charred and completely destroyed.

— For record protection containers intended for storing magnetic data processing disc and tapes and photographic films, one additional functional requirement is that the interior humidity should not exceed 85 percent in addition to temperature limits of 65°C or 50°C. The fire resistant record protection devices are required to be so constructed that doors, drawers or other closures, locking mechanisms and other movable parts shall be capable of repeated operations prior to fire resistance evaluations and repair of such parts can be made without damage to insulation.

Quality Control with respect to Fire

The science of protecting records from fire caught a sound footing about the year 1910 when Underwriters' Laboratories Inc (UL) conducted the first evaluation in which the temperatures of the furnace and of the air inside the record container under evaluation were recorded. About the early fire resistance evaluations on record containers carried out in the UK or in Europe, no literature or record is available. The record container first evaluated at UL was lacking in fire resistance and the evaluation procedure was also crude as compared with present day evaluation procedures. In the case of walls, floors, doors, etc, evaluated prior it was possible to see the exposed and the unexposed sides of the test specimens. As it is not possible to see what happens to the records in the interior of the record container surrounded by fire, only possibility remains is to measure the inside temperature by any remote reading thermocouples. So measuring temperatures inside record containers during evaluation and cooling period naturally called for fixing of a maximum permissible temperature to check fire resistance rating of record containers. The temperature rise inside the record protection device is influenced by the temperature of the furnace. So during developed of modern evaluation procedures definite schedule of furnace fire temperature (standard time-temperature history) and closer furnace control were felt as a necessity.

The maximum permissible interior temperature was set to be 177°C, keeping in view that the charring/ignition temperature of most of the paper records is somewhat higher than this temperature. This limit was set before the standard time-temperature curve was adopted for furnace fire control. Adoption of a temperature rise limit made it easier to grade the record containers quantitatively.

Record containers for storing magnetic data processing and photographic media have been developed. As the interior temperature and humidity affect the integrity of these media so the maximum interior temperature and humidity of 65°C and 85 percent respectively have been fixed as a limit for such type of record containers during fire resistance evaluations.

Experiments have shown that some magnetic media loose their integrity at temperatures above 50°C and in an atmosphere of RH 85 percent. So record containers having a limit of maximum temperature 50°C and RH 80 percent are also being manufactured now-a-days.

The record protection equipments are classified and rated in terms of an interior temperature limit, relative humidity limit and time in hours. Ratings as per various national and international standards are assigned to the various categories as follows :

Insulated Record Containers for : (As per UL : 72)

magnetic media	150 (65°C)-4 hour
	150 (65°C)-3 hour
	150 (65°C)-2 hour
	150 (65°C)-1 hour
insulated record containers for	
paper records	350 (177°C)-4 hour
	350 (177°C)-2 hour
	350 (177°C)-1 hour
safes	350 (177°C)-4 hour
	350 (177°C)-2 hour
	350 (177°C)-1 hour
insulated filling devices	
	350 (177°C)-1 hour
	350 (177°C)-½ hour

The position of thermocouples for measuring temperature inside the record containers for record media, and papers; for safes and insulated filing devices is different in each case and is given in the Table 1.

Table 1 clearly gives a picture that American and European standards are similar as far as position of thermocouples for measuring inside temperatures are concerned. However, the Japanese standard differs in case of position of thermocouples and also about the interior temperature limit. The diameter of thermocouple wires and type of thermocouple is also different in case of JIS S 1037.

The procedure for heating, impact, and reheating during evaluation is different in American, European and Japanese standards. The procedure is given in Table 2.

Although the US standard emphaes the importance of impact due to fall from a height of 9.1 m whereas usually most of the buildings, banks, commercial and financial institutions do not have a floor to floor height of 9.1 m.

The rated record protection equipments are also subjected to a sudden exposure to 1000°C temperature for 30 minute. These should not explode as a result of such exposure. This criteria is specified in standards of most of the countries.

Selection of Rated Equipment

The selection of the class of record protection device depends upon the type of records to be protected, type of building and occupancy, and the severity and duration of fire, a complete burn out of the room or section of the building in which the record protection container is housed.

During fires in non fire-resisting buildings floors may collapse and may fall on the record protection devices and/or record containers may fall through one or more stories so the assessment of resistance of record protection containers to impact in heated conditions becomes necessary. In such locations heat resistance and impact resistance record protection equipment should be used. The following paragraphs describe where particular type of equipment should be commonly housed.

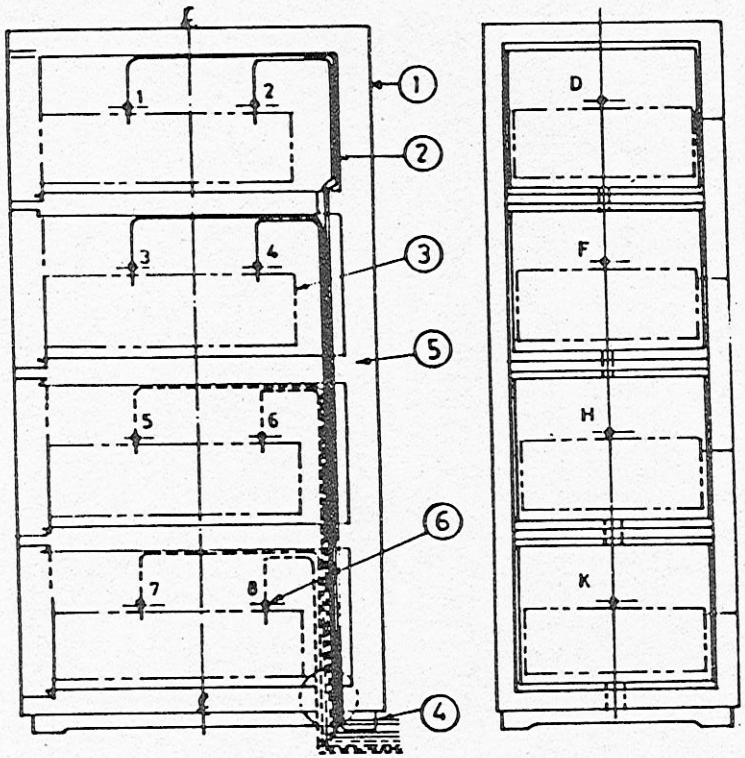
— Four hour fire resistance rating record protection equipment should be used for protection of vital public records, important company

TABLE 1 POSITION OF THERMOCOUPLES FOR MEASURING INSIDE TEMPERATURE

Standard	Record Containers 350 (177°C)	Record Containers 150 (65°C)	Safes 350 (177°C)	Filing Devices 350 (177°C)
NFPA-232	Four thermocouples 50 mm from top, 25 mm from sides, back and drawer heads/ door(s)	Four thermocouples 25 mm from all interior surfaces except bottom	Four thermocouples 150 mm from top Two thermocouples 150 mm from back 25 mm from sides. Two TC 25 mm from door(s)	Centre of interior compartment or not more than 190 mm from any interior surface
UL : 72	-do-	-do-	-do-	-do-
FOC Recommendations for the protection of computer installations against fire Appendix-III	—	Four thermocouples 25 mm for all interior surfaces except bottom	—	—
JIS S 1037 Fire resistive safes	Four thermocouples (CA) 150 mm from top 505 mm from back, sides and door(s) inside temperature limit 180°C	Four thermocouples 150 mm from top 505 mm from back, sides and door(s)	—	—

TABLE 2 FIRE AND IMPACT TEST

Standard	Testing Procedure for Classifications			
		350 (177°C)-4 hrs 150 (65°C)-4 hrs 150 (65°C)-3 hrs	350 (177°C)-2 hrs 150 (65°C)-2 hrs	350 (177°C)-1 hrs 150 (65°C)-1 hrs
NFPA-232	Heating	—	—	—
	Impact	9.1 m	9.1 m	9.1 m
	Reheating	—	—	—
	Cooling	—	—	—
UL : 72 : 1983	Heating	60 min	45 min	30 min
	Impact	9.1 m	91. m	9.1 m
	Reheating	60 min	45 min	30 min
	Cooling	Should remain in the furnace for cooling till 45°C temperature is reached		
FOC Recommendations for the protection of computer installations Appendix III	Heating	90 min according to ISO 834 : 1975		
	Impact	4 m on concrete rubble 50 cm thick time interval not more than 20 min		
	Reheating	30 min at 900°C attained quickly		
	Cooling	Water cooling immediately after the end of heating period		
JIS S 1037-1981	Heating	60 min	45 min	30 min
	Impact	4 m	4 m	4 m
	Reheating	60 min	30 min	30 min
	Cooling	Rapid cooling after the evaluation is specified in JIS S 1037		



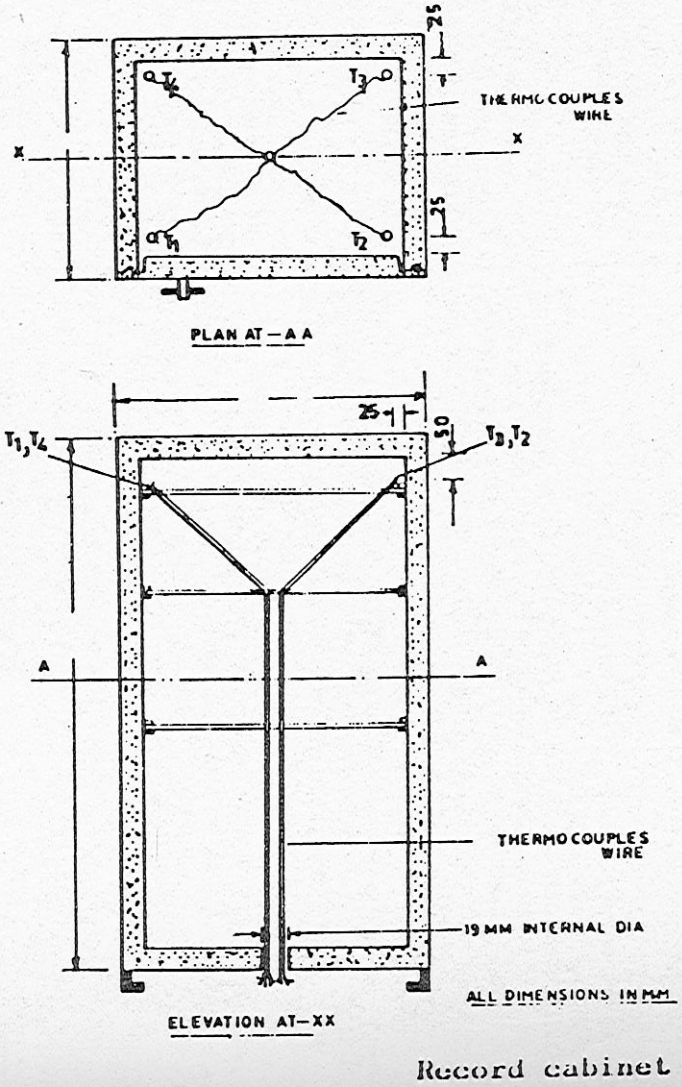


Fig. 1 Layout of thermocouples for measuring inside temperature

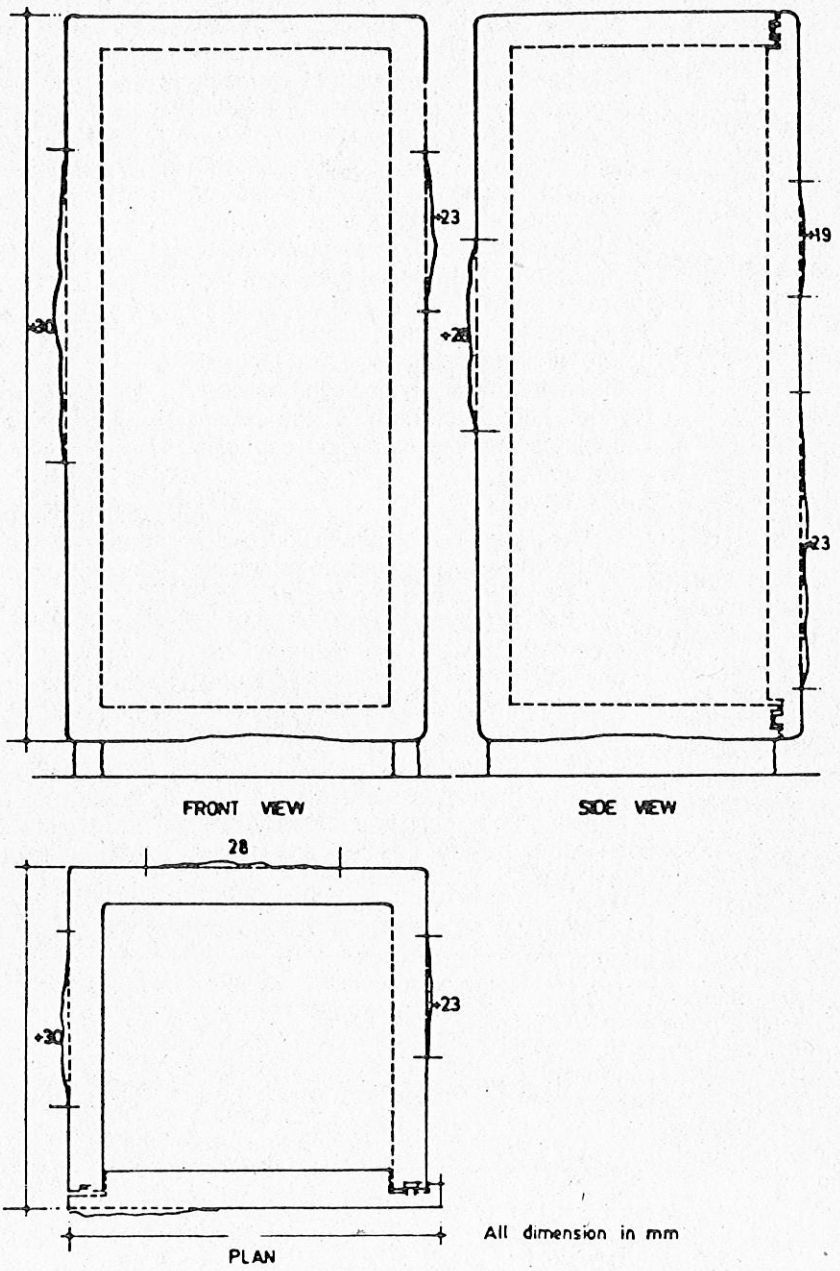


Fig. 2 Record cabinet after two hours fire and impact test

records, etc, when these protection equipment are housed in non fire resistive buildings, and in fire resistive buildings having large quantity of combustible contents and materials, for example, a congested file storage area, factory, store and a warehouse.

— Record protection equipment of two hour fire resistance rating are suitable to protect records when housed in any type of building have medium fire load of materials like desks, tables, chairs, filing cabinets, cupboards, open containers for papers, files and registers.

— Equipment with one hour or higher fire resistance rating with impact are suitable for protecting record in one storey non fire resistive buildings and also in fire resistive buildings of any height, having fire area in the vicinity of the record container of moderate quantity of combustible materials.

— One hour fire resistance rating record protection containers without impact are expected to give protection against a complete burnout only in a fire resistive building having small quantity of combustible material placed in the open. In such buildings the furniture should be of steel and majority of combustibles should be kept in these steel cabinets. Openly burning combustible material produces heat three times more than combustibles burning within a non-ventilated encloser.

Conclusion

The Fire Research Laboratory (FRL) at the Central Building Research Institute, Roorkee, has established the standard facilities for providing the technical aid to industries for assessing not only the quality of the products but to suggest suitable modifications for their upgradation.

The FRL is equipped with two large furnaces provided for fire resistance evaluations on horizontally and vertically disposed space dividing elements of structures. These are oil fired with LPG pilot flame burners having automatic ignition system. Among special features, capability of realizing not only the standard time-temperature curve but any desired and pre set time-temperature pattern, means of controlling the furnace pressure, and induced draught system that permits handling of only cold air by the fan, a remote controlled hydraulic loading arrangement and adequate safety of inter-locking system. In consequence, the furnaces are also suitable for fire resistant research. The floor furnace with ten long flame burners, five each in opposite long walls of size 4.57 m × 3.00 m and is being used for evaluating record protection equipments Figure 1 shows the layout of thermocouples for measuring inside temperature of filing cabinets. Table 3 gives the method of filling insulation between inner and outer body of the record cabinets and the insulating capability accordingly.

The experience of carrying out evaluations on record protection equipment has led to conclude that factors affecting fire resistance performance of record containers are chemical and physical nature of insulating material; filling methods of insulating material; mechanical design of door/drawer front of record protection equipments; hinges, their type and positioning; shooting bolt, number and positioning; U groove design, its fitting and gasket material; pressure releasing holes in the outer body of the cabinet.

Sometimes during the evaluation it was also observed that the cabinets having same construction may give different ratings when evaluated for fire endurance and fire and impact. This may be due to improper design of the protection equipment to bear the impact of free fall on the floor. Figure 2 shows the deformation in fire resistance safe after impact.

Further, the cooling mechanism and type and size of furnace employed during evaluation make lot of differences. For example, if a cabinet is evaluated in a small furnace the rating obtained for fire resistance will be quite higher than if the same is evaluated in a large furnace even after assuming that the time-temperature curve was maintained in both the cases. Similarly, if after the specified duration the cabinet is taken out from the furnace and cooled by the application of water, the rating will be higher if the cabinet is kept within the furnace even after the specified period and after stopping the furnace.

Thus, it can be safely concluded that quality control is an essential phenomenon in the present scenario of open economy and is only successful if a sincere cooperation between manufacturers, standard organizations, users industry and above all the evaluating agencies with standard equipments, qualified, capable and sincere staff is maintained together with all time efforts in maintaining frequency of evaluation, time limit for the evaluation of report and through upgrading of the available know-how.

TABLE 3 COMPARATIVE PERFORMANCE OF INSULATING MATERIALS

TYPE	MAX. TEMP. INSIDE THE CABINET
Cabinet-1	145°C-190°C after 120 min
Cabinet-2	135°C-145°C after 120 min
Cabinet-3	177°C-234°C after 92 min