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FIRE PROTECTION IN SWEDEN

by

D. I. Lawson

Summary

This report deals with a visit made to Sweden during March, 1958. It describes the fire precautions in tall blocks of flats, the work of the Central Office for Swedish Fire Loss Statistics and the State Testing Institute, and gives some information on the work of the Fire Services and the Fire Protection Association.

April, 1958.

Fire Research Station,
Boreham Wood,
Herts.

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FIRE PROTECTION IN SWEDEN

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D. I. Lawson

Reports of fire research programmes carried out in Sweden have reached this country from time to time and these have been parallel to many of our own investigations. There have been references to fire tests in high buildings which are particularly important at a time when this country is so interested in the provision of escape routes from the multi-storey flats at present being built. Some years ago the Swedish Fire Brigades were to have made comparative tests between high and low pressure water sprays in order to determine their relative efficiencies. It was found however that the latter tests had not been carried out.

A short visit lasting one week was planned during March, 1958, to find out the current trends in fire protection. The following people were interviewed:-

(1) Mr. Ingvar Strömdahl, Chief Inspector of Fire Services in Sweden.
(2) Captain Stålemo, Fire Inspectorate.
(3) Mr. Skogsberg, Chief Fire Officer, Stockholm.
(4) Mr. Palmquist, Stockholm Fire Brigade.
(5) Mr. C. Möller, Director of Swedish Fire Protection Association.
(6) Mr. Östlin, Swedish Fire Protection Association.
(7) Dr. Otto Brauns, Swedish Wallboard Industry.
(8) Mr. Eriksson, Swedish Wallboard Industry.
(9) Dr. Forstman, Director of State Testing Institute.
(10) Mr. Jonsson, State Testing Institute.
(11) Mr. Mårtenson, State Testing Institute.
(12) Mr. Larson, State Testing Institute.
(13) Mr. Billberg, Chief Inspector of Explosives, Department of Commerce.
(14) Mr. I. Sternberg, Central Office for Swedish Fire Loss Statistics. Karlävagen 40 - Stockholm Ö
(15) Mr. Johannesson, Civil Engineer, Secretary of the Committee of the Rural Building Board dealing with Bye-laws.
(16) Mr. Kling, Civil Defence Administration.

HIGH BUILDINGS

It had been known for some time in this country that buildings of ten or more storeys and having only one escape staircase were being erected in Sweden. This appeared to be an attractive method of reducing building costs here, but some apprehension was felt as to whether it would ensure an adequate standard of safety for the occupants.

In order to find out the Swedish experience in these matters the Chief Inspector of Fire Services and Mr. Johannesson were interviewed at different times. They stated that up to five years ago high buildings had been erected as dwellings to a height of nine to ten storeys, and up to two years ago a normal staircase without any special fire protection had been provided. In addition to the staircase in the block, each flat was provided with a balcony from which the Fire Brigade could rescue people. The Fire Brigade accept the principle that their ladders can be regarded as an alternative means of escape for buildings up to eight storeys though some fears were expressed that tall buildings were now being put up in rural districts, and in these areas the Fire Brigades were small and had no turn-table ladders. So far as is known there has been as yet no dangerous fire in high buildings and certainly no loss of life.

Last year new regulations came into force (copies of these are available) dealing with these buildings. One staircase is allowed for floor areas of 300 - 400 square metres, but above 450 square metres two staircases should be provided. It is thought most dangerous for the staircase to extend into cellars below the buildings where materials might be stored. This would give rise to basement fires giving quantities of smoke since the combustion would be incomplete, and the smoke would find its way up the staircase. It is accepted that there will have to be room below the ground floor to accommodate lift equipment, but this is felt to be relatively safe as there is no likelihood of storing material.

The Fire Brigade formerly required a dry riser on these buildings with a connexion at every five storeys to supply a 1½-in. hose line. Now the requirement in new buildings is that there must be a connexion into the dry riser every three storeys.

In order to allow the smoke from any fire to clear from the stairs, a chimney was provided at the top of the stairs and this was closed with a trap door operated by a steel wire passing through a conduit to a winch on the ground floor of the building. This had not proved satisfactory for two reasons first, because in summer the temperature inside the buildings was often lower than that outside, so that there was no differential head to provide ventilation of the smoke and secondly, it was found that the winch arrangement did not always function. When an inspection was carried out over a number of these winches in Stockholm it was found that half did not work due either to corrosion or to their being painted.

It is proposed to use a mechanical ventilation system with a motor and fan on new buildings. This will normally be used for ventilating the building and the fan will be connected to the ducts running to the various rooms of the building. In case of fire, by opening a trap door in the fan room, the ventilation system will be switched from the ventilation ducts to the staircase. This is by virtue of the fact that the resistance of the staircase to air flow will be much lower than that of the ducts. The trap door will be operated either by a winch or by a fusible link, and the system is to be now maintained by the chimney sweeps so that it will be kept in good order. The chimney sweeps are a more responsible and organized body in Sweden than is the case in this country (see page 5).

The fire protection in multi-storey flats is very well explained in Report No. 37 of the State Board for Building Research. This contains a discussion of the problem of escape from high buildings, and deals with the cost of various fire protection measures which may reach as much as 10 per cent of the building cost depending on the degree of protection provided.

In order to get some idea of the risk to the inhabitants, comparative statistics are given in this report for both wood and stone dwellings in Sweden; excluding deaths from some extraneous causes such as smoking in bed, it would appear that incombustible constructions are about 10 - 20 times as safe as wooden houses. The report also deals with the spread of fire between houses and attempts to evaluate the risk of spread in multi-storey buildings. A survey that had been made shows that in only one fire in 3,000 is there spread from one floor to another.

STATE TESTING INSTITUTE

The State Testing Institute has a total staff of about 150 and is concerned with tests on electrical apparatus and building materials; the latter, of course, include fire tests on both building materials and construction.

The Fire Testing Section has a small permanent staff (about 4) but it is possible to draw in other people when any full-scale fire tests have to be conducted. The section has a wall furnace and a floor furnace the latter is, unfortunately, out-of-doors and therefore cannot be used in winter time.

Recently attention has been devoted to a box test in order to estimate the contribution of wall linings to the growth of fire. This was originally developed by the Swedish Wallboard Industry, but the apparatus has been completed by the State Testing Institute. It consists of a box lined on both the sides and roof with the board under test and a propane/air burner is placed near to one of the sides.

The wallboard is assessed by the way in which the temperature of the flue gases issuing from the box varies with time. The test in principle is not unlike the one developed by the Joint Fire Research Organization. The amount of smoke which issues from the wallboard during combustion is monitored by a photo-electric cell near the flue outlet.

A number of tests in a room 10 ft wide, 20 ft long and 8 ft 6 in. high, lined with various boards on all the walls and ceiling, but with an earth floor, have been carried out. The fire develops in an auxiliary chamber attached to one end which has dimensions 10 ft long x 5 ft wide x 8 ft 6 in. high and the flames issue into the larger compartment through a door of normal dimensions. The flash-over criterion is used and the Box Test has been standardised to these fire tests by controlling the flow of propane gas to the burner.

During last year this section carried out the full-scale fire tests in compartments representing those of a multi-storey building, which have been mentioned previously.

Other apparatus is available for testing roofs and this test is the same as that carried out by the Underwriters' Laboratories. Burning brands of various sizes are placed on the roof and an air current is blown over them. The roof is graded, according to the size of brand it will survive without penetration.

Extinguishers

This section carries out tests on fire extinguishers and was interested to learn of our experience in the testing of dry powder extinguishers, and in particular whether there was any information on the performance of extinguishers in which the body was pressurized. They also mentioned that experiments had been carried out in Germany with dry powders which contained ammonium sulphate and they had been effective against solid fuel fires.

Factory roofs

It was stated that for factories employing more than 200 people the factories must have a fire-proof construction, and the roof was usually of light-weight concrete. Some old factories had 1-in. timber roofs, and these were thought to be dangerous.

Some experiments are described which were carried out to determine the means of escape from balconies. It was tested whether it would be possible for a person to survive behind a partition on a balcony long enough for a rescue to be effected, when flames were escaping from a window on the other side of the partition. The partition was found to be ineffective and the balconies are now only regarded as amenities and places to escape from smoke. Incidentally it was stated that in no case yet had balconies been used as a means of escape from fire.

CONSTRUCTION

Multi-storey buildings are usually made of reinforced concrete and the outer walls are of stone. Sometimes a wood beam construction is used with curtain walls of incombustible material.

No exterior wood is allowed on the building but there is no control of the amount of glass that can be used on the facade; this has not so far been a problem in a climate that often gets periods of 30° of frost, as it would be difficult to get the insulation required with large windows. However, now that buildings are being put up with treble windows large glazed areas may be feasible.

It is very necessary to provide thermal insulation of the floor slab where it abuts the building facade. This is effected by a plug of rock wool or by using foamed concrete. The inside linings are generally of plaster and gypsum board. Neither fibre insulating board nor wood is allowed, though, of course, there is no control over what the tenants may use once the building is erected.

The doors between flats are rated at ½-hour fire-resistance, and where fire doors are provided on to the staircase, as shown in the Building Code, these have a fire-resistance of 1 hour.

The question of the fire spreading along the ventilation ducts into the plenum and thence to other floors was raised and the Swedish authorities stated that all of these ducts were 5 cm (2 in.) thick concrete and that the flames would not be drawn into the ducts once the ventilation trap door was open.

WALLBOARDS

Sweden, Finland and Norway together produce about half the fibre wallboard output of Europe. There are no state laws as to its use generally, except in high buildings. The use in public buildings is controlled by the Fire Brigade in each community; in private houses there is no control except that which may be exercised by the Insurance Company.

No treatment is placed on the boards before they are sold, as this tends to cause warping, which is undesirable. One firm only is making an impregnated wallboard.

Some time had been spent developing a fire-retardant treatment by the Swedish Wallboard Industry, and a successful type of paint had resulted. This, however, had not been produced but had been used as a weapon to induce an American exporter of international reputation to keep his prices low.

The Testing Institute had been asked to carry out a test on a proprietary British roof, and for this a section of a factory had been built about 40 ft long, 10 ft high at its highest point and 10 ft wide. The roof was sloping, being about 6 ft at its lowest point. A crib of timber having a weight of about ½ ton was placed at the lowest end. The roof section was an aluminium trough construction, and on top of this was placed 2 in. of foamed polystyrene, the outer surface being covered with a felt to a depth of ¾ in. The foamed polystyrene melted and the roof was ignited on the outside.

CHIMNEY FIRES

Chimney sweeping in Sweden is taken much more seriously than in this country. All cities and towns have a fire ordinance requiring chimneys to be swept regularly.

Each district is under the control of a chimney sweep and his staff who are licensed after having attended a Fire Protection Course for chimney sweeps at the Fire College. They operate privately under licence, and have a list of all the chimneys in the district and are responsible for their regular sweeping. The frequency of sweeping varies according to the chimney and fuel. For example, the chimney of a kitchen stove burning wood fuel must be swept every year. Central heating systems using oil or coke fuels are swept four times a year, whereas if the fuel is wood the chimney must be swept twelve times a year. Steel bristled brushes are used for sweeping.

In rural communities there is no legal enforcement of chimney sweeping, though many have adopted the same system as in cities and towns.

The law regarding chimney sweeping came into force in 1944. It is not possible to say whether it has been effective in reducing the number of chimney fires because during the war, due to fuel restrictions, a good deal of wood was used, and this caused a lot of fires and damaged a lot of chimneys.

It was learned later that the fire losses during the period of the war increased and that every restriction on coal fuel brought about its consequent increase in fire losses (see page 11).

It was stated on several occasions that this was due particularly to the operation of stoves with the same air throughput as had been used for coal fuel, thus producing a hard glossy deposit in the chimneys which readily caught fire and burned fiercely. The temperatures measured in tests had amounted to 1,300°C. Later it was found that these difficulties could be avoided to some extent by alternating the wood fuel with coke. This seemed to change the soot from a hard glossy deposit to a more expanded soft type which could readily be swept out.

In the period when wood fuel was used exclusively the chimney would become almost closed by the soot; then if a fire started the consequent increase in pressure in the flue forced the flames out through any cracks.

The numbers of chimney fires in relation to the total number of fires appears to be much smaller in Sweden than in this country; for example chimney fires amounted to a total 2,000 out of 6,000 fires attended by the Brigades in 1946. With the lifting of war-time restrictions on fuel the figure seems to have decreased markedly. In Stockholm there were 106 chimney fires out of a total of 1,999 fires in 1953, and in 1954 there were 76 chimney fires out of a total of 1,775 fires.

The Fire Service gets about 60 per cent of statistics from all the Brigades, but these are not collected according to a uniform pattern. It is hoped to unify this throughout the country.

FIRE BRIGADE EQUIPMENT

It was explained that the Fire Service would become part of the Civil Defence Administration in war-time. In peace-time the two organizations are separated, though they naturally work together in purchasing stores of fire equipment which may have to be used in war-time.

Hose

The Fire Technical Section of the Civil Defence Administration provides a room for hose tests with a staff of two and 20,000 kroner (about £1,400) is made available for these tests. This encourages manufacturers to supply new products for test in the hope that they will be adopted both by the Fire Service and for stockpiling for war-time. Two sizes of hose are in use in Sweden, $1\frac{1}{2}$ in. and 3 in. The $1\frac{1}{2}$-in. hose is in lengths of 230 ft and is flaked in a box, having a loaded weight of just over 50 lb. It is thus able to be carried by a man with comparative ease.

The following measurements are made on hose:-

(a) Weight/metre

(b) Flexibility

(c) Diameter

(d) Thickness of wall

(e) Bursting pressure. The acceptance limit for a 3-in. hose is 490 Lb/in^2 and for a $1\frac{1}{2}$-in. hose it is 630 Lb/in^2. The $1\frac{1}{2}$-in. hose will stand a pressure of 1,000 Lb/in^2 so that the 630 Lb/in^2 limit may be increased. During the test the pressure is increased to the acceptance limit and reduced again 20 times, each operation taking 1 minute. The pressure is then increased to the acceptance limit and maintained there for 1 hour. After this the pressure is increased until the hose bursts.

(f) Extension under pressure. The increase in length under pressure must not exceed 10 per cent.

(g) Increase in diameter. The increase in diameter when the pressure is equal to the acceptance limit must be greater than 5 per cent, but less than 10 per cent. The lower limit is to allow some expansion should there be freezing in the hose, and the upper limit is determined by the fact that the hose must be fastened to a coupling of fixed diameter, and it is thought that any large change would cause strains at this point.

(h) Drying test. The hose is washed in water to which a detergent has been added, it is then rinsed, shaken out and dried under controlled conditions.

(i) Adhesion of lining

(j) Ageing test. The hose is kept at 70°C in air and its condition studied at the end of one week. There is no objective method of studying ageing, but it is felt that this might show up some defects.

It is intended in the future to carry out a low temperature test on both wet and dry samples of hose at -30°C; observations will be made on the appearance of the hoses.

Fire pumps

During severe winters difficulties are sometimes experienced due to fire pumps freezing, and this has been overcome by providing a hot water jacket and supplying this from the radiator of the engine. Another type uses the exhaust gases from the engine as a source of heat. These are passed through a jacket round the pump. The latest type, however, has no jacket, instead use is made of a clutch drive from the engine. In this case should the pump freeze and seize, the clutch will allow the engine to run while the pump is thawed out by blowing hot gases over it from the engine exhaust. This pump, which was stated to be an improvement on its two predecessors, would pump 160 gal/min at up to about 140 Lb/in^2. Drawings both of this pump and the standard hoses and couplings in use will be available shortly.

Breathing apparatus

The Chief Inspector stated that the Fire Brigades favoured compressed air rather than oxygen breathing apparatus for a number of reasons. The equipment is lighter and more comfortable for the men, as the air from the compressed air cylnder is cooler and there is not the complication of removing the carbon dioxide from the respired air as is the case with oxygen. Moreover, compressed air cylnders can readily be refilled on site. On the other hand, the compressed air equipment lasts a shorter time than the oxygen equipment, but it is felt that 20 minutes is long enough for any man to work in conditions where breathing apparatus is necessary.

When this apparatus is in use men are always sent in pairs and they keep together; telephone and walkie-talkie communication systems have been tried, but a rope or a hose is now used to find the men inside the building. There have been no casualties to date.

SWEDISH FIRE PROTECTION ASSOCIATION

This has a staff of 15 and derives 80 per cent of its income from the insurance companies, the other 20 per cent being largely provided by members. The State provides 2,000 kronor (£140).

Seventeen films in colour have been prepared for propaganda purposes. Some were shown illustrating the dangers from welding and cutting and the simple measures by which these may be prevented. Another film taken on board ship indicated how fires were started in ships and how these could be avoided. The Swedish Fire Protection Association have arranged for children to get four hours instruction on fire protection during their last year at school; two excellent colour films have been made for this purpose and the third is to follow shortly. The films are made in conjunction with a film laboratory in Stockholm, one member of the Association having this part of the work under his control

Recently, the Swedish Television Service has allowed the Fire Protection Association time to put over information on fire prevention. In addition to this work the Association publishes the journal 'Brandskydd' which is free to its members.

The technical standard of this Association is very impressive, and although it is small, it appears to play a very active rôle in fire protection matters in Sweden. It is consulted on all building codes and appears to be very up-to-date in its information. This Association mentioned that a number of plastic materials were being used in Sweden for unsuitable purposes. An example was given of some heat-resisting plastic finishes which had been put on the market, and these, though they would resist the burning from a cigarette end and hot containers, nevertheless spread flame very rapidly, and were dangerous on this account. The Fire Protection Association had been instrumental in having these withdrawn from the market. Plastic sheets are still being used to cover window openings while buildings are being constructed in Sweden; this is necessary to protect the workers during the Swedish winters. The fire risk occasioned by these is causing some concern.

GAS EXPLOSIONS

Last December a number of experiments were carried out under the sponsorship of the Scandinavian Airlines who were interested in the consequences of dust and vapour explosions that might occur in engine servicing workshops. They were particularly interested in the venting of buildings to withstand an explosion. These tests were under the control of Professor Hildebrand of Uppsala University. A building which was about 12 ft high, 18 ft wide and 24 ft long was put up to withstand pressures of 1,000 kilograms per square metre, (about 1·4 Lb/in^2). One of the 24-ft sides was open, except for a section 3 ft wide adjacent to one corner.

In this open section one series of experiments was conducted with steel panels clipped to cover the opening, and other experiments made use of frangible panels of foamed plastic. For most of the explosions a 6 per cent propane/air mixture was used. The early explosions were carried out in a meteorological balloon inside the building. This was filled first with 750 cubic feet of gas, and exploded; then further explosions were carried out with 1,200 and 2,100 cubic feet of gas, and finally, when these were found to be safe, the whole building was filled with the flammable mixture. The explosions were filmed with high speed cameras and oscillographic records were taken of the pressures. A report is at present being written.

Typical values of the pressures were, for propane, and air, 0·5 Lb/in^2, and for a later series of experiments with a 12 per cent acetylene/air mixture, about 1 Lb/in^2.

INSPECTORATE OF FLAMMABLE LIQUIDS AND EXPLOSIVES

The Inspectorate of Flammable Liquids and Explosives controls the storage and movement of petrol as well as the common explosives. In the near future it is expected that this control will extend both to diesel and fuel heating oils.

Explosives are classified in eight groups from A to H for transportation. Group A contains the most dangerous materials, for example, nitroglycerine, while H contains those for which no special precautions need to be taken, except that they are labelled "Explosive".

Organic peroxides are usually mixed with 30 per cent tricresyl phosphate or 10 per cent water, and this brings them into the lowest class for which no special precautions are necessary. Amounts of up to 60 kilograms are stored in specially insulated iron cases and this is thought to be more than adequate for any industry to store at any one time.

There are no special tests for grading the categories of liquids for transportation and these gradings are made after reference to the literature. The grading is usually decided by the fire point and sensitivity to friction.

Two reports were mentioned (1) (2) relating to the transport of dangerous goods and to organic peroxides.

A Conference had been held in Chicago on the handling of petroleum products and the measures which should be adopted to prevent ignition from static electricity. Four of the reports (3) (4) (5) (6) from this Conference issued by the Shell Company in Holland and the Esso Company in America seemed to be a marked advance on anything that is known at present.

CENTRAL OFFICE FOR SWEDISH FIRE LOSS STATISTICS

This Organization collects the fire loss statistics from a large group of insurance companies, representing about 75 per cent, (10,000 fires), of the total claims. These are coded in such a way that each fire has a number and counts only as one fire irrespective of whether several companies bear the loss.

The statistics have been collected since 1922, so that there is a good deal of fire experience contained in these. In ascertaining causes the office pays particular attention to small fires, as it is more easy to assess the cause and therefore the information in this respect is likely to be more accurate than for large fires.

Figures relating to the cost and numbers of fires for the period 1948 - 52, are shown in Table 1.

Table 1

Distribution of cost and number of fires (1948 - 52)

Losses in Kr.	Cost per cent	Number of fires per cent
> 100,000 (£7,000)	54·8	0·92
> 200,000	43	0·44
> 300,000	35·6	0·27
> 400,000	30·6	0·19
> 500,000	26·1	0·14
>1,000,000	14·2	0·04

The corresponding figures for the period 1938 - 47 are shown in more detail in Table 2.

The losses, as in the United Kingdom, occur as a result of relatively few large fires. Apparently for losses of less than 100,000 Kr., the figure is fairly constant from year to year. Only the losses above 100,000 Kr. fluctuate, and each of the peaks on the curve can be identified with large fires that have occurred; this is shown in Fig. 1. In this figure all the costs are relative to the prices current during 1935.

The peaks correspond to the following fires:-

Elektrolux - 1936, Mölnlycke - 1940, Nol-Tingstad - 1944 and Skoghall - 1947.

The costs of fires in relation to causes is shown in Fig. 2. The fires for which the causes are known are normalized 100 per cent, those above 100 per cent relate either to unknown causes or to extraneous causes, for example, fire spreading beyond the building of origin.

The incidence and costs of fires at various times of the day are shown in Fig. 3, the width of the boxes representing the numbers of fires in each hourly period and the height of the boxes representing the costs. This is similar to the situation in this country, where the most costly fires occur in the early hours of the morning.

Table 2

Distribution of fires (1938 - 47)

Cost of individual fires			Number of claims		Cost of claims	
	£	£	% of total	Number	% of total	Cost £
		<7	35·01	48,003	0·34	156,724
Between	7	35	33·82	46,362	1·58	731,550
"	35	69	8·73	11,969	1·24	575,073
"	69	138	6·05	8,296	1·74	804,836
"	138	205	2·89	3,961	1·44	665,191
"	205	275	1·89	2,595	1·34	619,093
	275	345	1·31	1,797	1·20	553,753
	345	690	3·73	5,108	5·39	2,496,956
	690	1,380	2·70	3,708	7·81	3,614,631
	1,380	2,700	1·84	2,517	10·59	4,902,764
	2,700	4,150	0·69	946	6·84	3,167,710
	4,150	5,500	0·36	489	5·01	2,320,795
	5,500	6,900	0·20	268	3·58	1,658,055
	6,900	13,800	0·45	616	12·65	5,859,132
	13,800	20,500	0·13	182	6·58	3,045,616
	20,500	27,500	0·06	83	4·23	1,957,070
	27,500	34,500	0·04	51	3·37	1,562,518
	34,500	41,500	0·02	29	2·34	1,085,445
	41,500	48,500	0·01	19	1·80	836,396
	48,500	55,000	0·01	20	2·24	1,035,620
	55,000	62,000	0·01	10	1·30	600,346
	62,000	69,000	0·01	15	2·09	972,111
	69,000	138,000	0·03	41	7·82	3,623,368
	138,000	205,000	0·01	9	3·30	1,530,397
	205,000	275,000	-	1	0·48	223,108
	275,000	345,000	-	1	0·61	284,274
	345,000	415,000	-	1	0·87	401,827
	415,000	485,000	-	1	1·04	480,829
	485,000	550,000	-	1	1·18	546,440
Total			100·00	137,099	100·00	46,311,628

The fire losses in terms of the value of the property insured are shown in Fig. 4, where it will be seen that the costs of fires have tended to rise recently as a result of the decreasing value of money, but the loss as a percentage of the value insured continues to decrease.

An interesting series of figures relate to the number of chimney fires during the period 1938 - 1947. These are shown in Table 3.

During the war three successive restrictions in fuel occurred, and these led to the increased burning of wood. The first occurred in 1940 - 1941, the second, 1941 - 1942 and the third in 1944 - 1945, and those are indicated by the horizontal lines in the Table. It will be seen that as each successive fuel restriction occurred the fire losses increased.

Table 3

Total fire losses due to chimney fires

Year	1938	1939	1940	1941	1942	1943	1944	1945	1946	1947
Number of fires	164	129	276	775	1 050	1 028	1 833	2 334	2 331	2 858
Losses in millions of Kr.	0·1	0·2	0·3	1·0	1·5	0·9	1·5	2·0	1·9	3·1

CIVIL DEFENCE ADMINISTRATION

Underground shelters in Stockholm

There are four large underground shelters at present in Stockholm which have been driven into the granite substrata and a further sixteen are contemplated.

The largest public shelter is about 70 ft underground. It is in the form of a hemi-cylindrical tunnel about 1,000 ft long and 50 ft in diameter. The tunnel-section is divided into three floors which accommodate a total of about 20,000 people. The various floors are entered from the road by a spiral ramp about 30 ft wide at each end and the main tunnel is sealed at the entrances by reinforced concrete doors 1 ft thick. Sealed interlock doors will admit late-comers.

Air to the tunnel is filtered, first to take out any radioactive products, and then it is passed through a large bank of carbon filters to take out any toxic gases. The metabolic heat from the tunnel inhabitants is removed by a cooling system in which ice-cold water is pumped round the pipes. The ice-cold water is supplied by a refrigeration plant, and a diesel engine power station provides electrical supplies.

The tunnel may be divided at its centre point by a fusible link fire door, so that the two halves can be separated in the event of a fire occurring in one end. The whole system is sprinklered and six fire points are situated at various intervals along the main shaft.

The tunnel itself is made of reinforced concrete and the walls are spaced 50 cm from the rock through which it is driven. This cavity is said to give extra strength and to provide a return path for the respired air.

The system cost 20,000,000 Kr. (£1,400,000) and is at present being used as a car park (600 cars) to defray the cost of building.

In addition to these public shelters, each major fire station has an underground shelter complete with control room, power supplies, kitchens and sleeping quarters. One which was visited would accommodate a staff of 100, together with fire engines, etc. The fire officer in this case was responsible for a district of 150,000 inhabitants in peace-time but in war a regrouping would take place so that the number would be increased to 250,000.

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