DANISH MARITIME AUTHORITY

Lessons to be Learned from the "SCANDINAVIAN STAR" Disaster

by

Hans Christensen
director deputy

On Friday 6 April 1990 at 21.45 hours the passenger ship m/s Scandinavian Star left Oslo, Norway. The destination was Frederikshavn in Denmark, with the expected arrival on the following morning. On board were 383 passengers and 99 crew members. During the voyage, in the middle of the night, a fire broke out. The fire was due to arson. The consequences of the fire were disastrous. 158 passengers never reached their destination.

The disaster created unrest among the general public in Denmark as well as other countries. The questions were, how could a disaster in such a scale happen, what went wrong? Could a similar accident happen in a Danish ferry? As the investigation later proved, there were no serious technical defects in the ship, all the officers had the necessary qualifications, and the crew was of a standard which can be found in many vessels around the world.

Nobody being able, during the time following the disaster, to issue an assurance against such an accident to happen in a Danish ferry, given the right circumstances - or for that matter in any ferry, regardless of flag - the confidence in the safety of passenger ships was eroded. In this connection it has to be realized, that ferries are very important means of transport in Denmark and when travelling to the other Scandinavian countries. In the year 1990 ferries in Denmark transported 62 mill. passengers, which is a considerable number, taking into account that the population of Denmark is little more than 5 mill.

Questions raised.

The main question was: Is the safety standard on board passenger ships lower than what is generally accepted in our society, or does it involve a special danger to use this means of transport?
As is often the case when a disaster of such a scale occurs, it was proved once more that the weak link was the human element. In many countries and internationally there is focus on the human element. Without doubt, improvement of the qualifications and in the attitudes among seafarers, owners, survey organizations etc. will lead to a greater safety.
This attempt should not, however, divert the interest from the possible improvement by technical means. Experience in many areas shows, that where reliable technical construction and/or installation can supply and support man, safety is improved. As ships become more complicated, as the size of the crew is continually decreased and as in many places it becomes difficult to engage qualified crewmembers, the validity of this point will increase.

The disaster also raised serious questions about some of the basic concepts concerning safety. Concepts which for many years have been basic for the safety structure. The questions were:

- Is stopping the ventilation still the most effective way to limit the spreading of the fire?
- How do we ensure that firedoors are and remain closed during a fire, but still allow people to escape?
- How should the expected behaviour of the passenger influence the arrangement of the escape routes, the wording and form of instructions and signposts?
- How can the operational command in an effective way monitor and control the development of a fire and at the same time direct and coordinate the efforts to limit the consequences in an environment as complicated as a passenger ship?
- Is it possible to develop a more qualified manner than the arbitrary one used to day, to evaluate the safety standard of any given ship?

Satisfactory answers to these and other questions have to be found in the not too distant future, if the risk of similar accidents to the one experienced here is to be reduced.

The cause of the disaster.

This paper will in some detail explain some of the most important factors which are believed to have been the cause. However, as it is common for an accident of this scale, the disaster was due to a number of causes, which unfortunately occurred at the same time, and they all contributed to the result. Even if this paper focuses on the technical aspects, it should be underlined that the main cause were factors which are only partly or not at all covered by the regulations, but which to a large extent are connected to qualifications, experience and attitudes towards the operation of passenger ships.
The official investigation carried out after the disaster concluded that the following conditions and factors played a significant role:

- the master had not taken the necessary action to train the crew in firefighting and evacuation,
- the ship was not properly prepared for the intended service,
- the qualifications of the crew with regard to safety were low,
- communication between the crew members was hindered by lack of a common language,
- the sound level of the alarms and loudspeakers was low and not able to warn the passengers of any danger,
- the arrangement of staircases and the corridors, where the cabins for passengers was situated, was complicated, making it difficult for the passengers to find their way around the ship,
- the visual signposts were difficult to understand and located in non visual positions,
- previous inspection of the ship failed to find certain faults and
- the fire protection of the ship was not satisfactory, even if the present regulations were complied with.

The ship.

The description of the ship given here mainly deals with the particularities, which are necessary for understanding the nature and the development of the fire.

The ship was built in 1971 in the Dubigeon-Normandie shipyard at Praireau-Duc in Nantes, France, as a combined passenger ship and car ferry.
The main dimensions of the ship were: length overall 141,60 m, beam 21,90 m and depth 7,75 m. The ship was constructed in accordance with SOLAS 60.
The ship was divided into 12 watertight compartments. The car deck was the bulkhead deck and the freeboard deck.
The space for cars and trailers extended the length of the deck, but casings were arranged along the sides of the ship. In these casings there were cabins for passengers, arranged in two levels. The ship was constructed with 8 decks, arranged as follows: Deck no. 1 was the tanktop, deck no 2 was arranged with accomodation for the crew, service and storeroom facilities and engine rooms, deck no. 3 was the cardeck, but had accomodation spaces on either side, deck no 4 was the deck situated in the sidecasing and arranged with accomodation like the deck below, deck 5 extends the full width of the ship and was arranged with cabins for the passengers, reception and storerooms, decks nos. 6 and 7 were arranged with restaurants, lounges and shops, and the bridge was arranged on deck no. 8.
The ship was divided into three fire zones by two main bulkheads.
The fire protection was made in accordance with method I. This method requires the use of fire resistant bulkheads, which have thermal and structural resistance in the event of a fire.
The bulkheads in the accomodation spaces were constructed of 30 m/m thick asbestos silicate, covered by a 1.5 m/m thick layer of laminate; in some places by two layers. The ceiling consisted of 10 m/m thick asbestos silicate covered by a 1.5 m/m thick layer of laminated plastic. The deck above the car space, deck 5, was insulated by a 75 m/m thick layer of vermiculite.

The doors to the staircases were A-60 class selfclosing fire doors. The doors were held open by magnetic catches, which could be released locally or from the bridge. The doors to the cardeck were A class selfclosing sliding doors. These doors were supposed to be kept permanently closed, but there was no indication on the bridge showing whether they were in open or closed position.
When the doors were released, the magnetic catches were to be permanently deactivated.
The cabin doors were B-15 fire doors.

The technical condition of the ship.

The investigation after the disaster concluded, that the construction of the ship and the standard of the equipment, which might have had an influence on the fire, was generally in accordance with the requirements and the standard for a ship of the given age.
A few inadequacies were found, however. A firedoor was missing on the saloon deck (deck 6), aft on the starboard side. The door is believed never to have been fitted. Three alarm bells were missing in relation to the fire and safety plan and are believed never to have been installed.
The sound level in part of the cabin area, where the fire took place, is believed to have been low.
Apart from the faults and defects mentioned, the technical condition of the ship and the standard of the equipment was satisfactory, and in some respect even above the standard for many vessels of similar type and age.

The development of the fire.

To understand the causes of the fire and the disastrous result, it is necessary in details to explain the development of the fire. The following explanation is mainly based on the report from the investigation committee set up within a few days after the disaster by Sweden, Denmark and Norway. Later the Bahama also became appointed to the committee.

The fire was probably started some time after 0200 hours on April 7, 1990. The site of ignition was almost certainly the corridor area on deck 3 adjoining the entrance to a stairway leading up to the cabin area. (Re. Figure 2). The cabins on this deck was not in use during this voyage. There is little doubt that the fire was ignited with a naked flame, about the size of a match or a lighter flame. The ignited material is assumed to have been a collection of paper, bedclothes etc. Two to eight minutes after the fire was ignited, the fire had attained an effect great enough to ignite the surface material on the bulkheads in the corridor. From this point onward the fire spread rapidly. One minute after the corridor surfaces caught fire, the whole cross section of the corridor was aflame. The fire was drawn to a nearby stairway, and smoke was drawn up through the staircase and into the corridor above connected to the staircase. Two to three minutes after the fire had started, smoke was observed seeping into deck 5, and two minutes later on deck 6. The fire was signalled from deck 5 by use of the press button alarm.

The flames also began spreading up the staircase, and when they reached deck 5, they were directed across the transverse corridor to the corresponding staircase on port side and down to deck 3. This spread went extremely fast. Witnesses have described it "a ball of fire" that flashed through the transverse corridor. Smoke also began seeping into the corridors from the staircase on the port side of deck 4. There was less smoke here than in the other areas, however, and after the fire no corpses were found in the corridors on the port side.

The primary, life threatening fire was now limited to the site of ignition, the starboard and port staircases and about half of the transverse corridor on deck 5. The material that was burning mostly consisted of the surface material in the corridors and in the staircases. The extreme rapid development of the fire during this phase was over in about 10 to 15 minutes. After this the fire spread more slowly from this area to the rest of the ship.

As mentioned the smoke was pouring into the corridors leading to the staircase on starboard side and the transverse corridor on deck 5. Within 5 to 8 minutes the smoke in some of the corridors contained carbon monoxide, so that anyone exposed to

the smoke would have lost conscience within 30 seconds. An accumulated fatal dose of carbon monoxide occurs within 3 minutes. In addition the smoke contained high concentrations of hydrogen cyanide (prussic acid), which can reduce the above mentioned time even more. The cabins in the areas affected was free for smoke as long as the doors into the corridor remained closed. When the ventilation system was turned off, possibly not before 02.30 hours, the smoke seeped in through the cabin doors, and the atmosphere became critical to the people present after about 15 minutes. During the next few hours the fire spread progressively along the corridors and into the cabins, where everything burned up and bulkhead panels and ceilings collapsed. The fire spread relatively slowly due to the lack of oxygen and the many physical barriers. The fire was not extinguished before 16.00 hours on Sunday, 8 april.
The fire doors is of great importance for the development of the fire, why the function of these during the fire will be explained. The doors in this ship is normally kept open by magnetic catches, which can be released from the bridge. One of the reasons why the limited initial fire developed into a major fire, was that no alarm was ever given from deck 3, where the fire started. This was probably due to the fact, that nobody was present to press the alarm button. Thus the firedoor leading from this zone to the staircase was never closed, and the fire was allowed to spread. If the door had been closed early enough, further spread could have been avoided. Most of the doors were eventually closed. Although it has not been possible to establish the exact time. However, some of the firedoors in the areas affected by the fire remained open during the hole fire. One of the doors, which remained open, was the door leading from the staircase to the cardeck in the portside, opposite the site where the fire started. This created a draught in the corridor, which greatly influenced the development of the fire. The firedoors greatly affected the course of the fire because, together with the ventilation system, they influenced the supply of air to the fire. Closing of the firedoors and turning off the ventilation is supposed to cut off the air supply. The fact that some of the fire doors remained open while others were closed, is one

of the main reasons why the fire spread so rapidly and why the smoke affected such a big area. Furthermore the transverse corridor between the starboard and the port staircase on deck 5 created favorable draught conditions.

Where the bodies were found.

Most of the bodies, 99 in all, where found in their cabins. About 25 per cent of these were found partly or completely inside the bathroom, often with towels over their faces. This type of reaction, where passengers seek to obtain fresh air rather than trying to escape through a smoke filled corridor, has also been noted in other fires. Those who were found in the sleeping compartment of their cabins, seem to have had varying reactions. Some were fully dressed, while others were only partly dressed, or in their underclothes, which seems to indicate that they have become aware of the fire at a relatively late stage. A good 50 of the passengers were found in the corridors, mainly in the aft part of deck 5. Conditions in the escape routes must have been extremely difficult with dense toxic smoke and little light. Furthermore the arrangement of the escape routes was complicated, involving many changes of direction, and some of the corridors had dead ends. About 20 of the bodies were found in the dead end corridors. There were doors in these corridors, but they were situated about 3 meters from the end of the corridor.

The critical factors.

The development of the fire proved beyond doubt that the material used to line the bulkheads, the ceiling and the deck in the corridors and staircases caused the fire to spread rapidly and produce large amounts of toxic smoke. The material used consisted of a core of non combustible material surfaced with laminated plastic about 1.5 mm thick. The calorific value was afterward tested to 48 MJ/m2. It should be noted that the required calorific value in SOLAS 74 is 45 MJ/m2 for such material. As can bee seen, the calorific value of the surface

material on this ship was only 3 MJ/m2 above the present requirement. Nevertheless, this laminated plastic was decisive for the rapid spread of the fire, especially since it formed an uninterrupted surface covering the walls and the ceiling in all corridors and staircases. If the surface in the ceiling had been made of a material having a much lower calorific value, this would not have allowed the flashover in the corridor and thereby restricted the spread of the fire. This has later been proved by a full scale testing of a corridor, constructed of the same material and creating conditions similar to the conditions of this fire. During the early intense phase of the fire large amounts of gray black toxic smoke were developed. Carpets and furniture had no particular influence on the development of the fire.

The fire doors also proved to be a very critical and decisive factor. In the corridors, where they closed before the area was ignited, they proved to be a very effective means to prevent the fire from spreading. Some of the doors were totally scorched on the side facing the fire, while on the other side no damage or only very limited damage could be observed. Some of the doors did not close, however, and allowed the fire to spread into the areas beyond the door. It is not known if some of these doors were closed at an early stage, and later opened for the passage of people and then afterward did not close again. There are at present no requirements in SOLAS for the fireresistance and the mechanical function of the self closing mechanism on the doors. The fact that some of the fire doors closed and others remained open also affected the course of the fire. Together with the ventilation system they influenced the supply of air to the fire. The open corridor between the stairways starboard and port on deck 5 created favorable draught conditions, which further helped the fire to spread rapidly.
In this relation it should be mentioned that during the 60th meeting of the Maritime Safety Committee in IMO (MSC 60) it was agreed that all existing ships should be fitted with smoke detectors and a sprinkler system. These measures will to a certain extent prevent a fire from developing unnoticed,

until it becomes critical and out of control. The sprinkler will prevent the spreading of the fire and also, at least to a certain degree, hinder the development of large quantities of smoke.

Some of the actions taken to improve the safety against fire

After the initial evaluation of the causes for the fire it was concluded that the protection against a fire on board vessels of this type was not satisfactory. Therefore, it was decided that the Danish Maritime Authority should take the necessary step immediately to increase the fireprotection in Danish passenger ships and also try to get a better control with the safety standard on board foreign ships using Danish ports. This should be done by issuing technical regulations. To speed up the process, it was decided that the normal consultation and discussion with the industry in this case could be omitted.

For some time a technical regulation for extra requirements for fireprotection equipment in passenger ships had been under consideration and had already been discussed with the industry. Originally this initiative was taken after a fire in a passenger vessel a year before. This regulation contained requirements to improve the firealarm system, fitting of smoke detectors in the escape routes, making a number of breathing appliances for use in smoke filled spaces available, increasing the number of firemens outfit, increasing the number of spare cylinders for smoke divers and fitting of an aircompressor for recharging cylinders. This regulation came into force 1st August, 1990. The requirements included in this regulation were later included in the report from the Committee as a recommendation.

One of the difficulties during the rescue operation was to find out exactly how many had been rescued, the names of those who had been rescued and those who were still missing. A technical regulation was drawn up requiring that all passenger ships must, before departing the port, register the number of all passengers and crew members. Ships which have passengers

onboard during the night must register the passengers by name. This regulation is also applicable to foreign ships using a Danish port as departure. The regulation came into force on July 1, 1990. These requirements were later included in the Committee's report as a recommendation.

Very soon after the fire it was suspected, that the reason for the fire was arson. As is often the case, one arson may inspire others. A detection system of the type installed on board Scandinavian Star is dependent on the presence of people, which not always, as was proved in this disaster, is the case. Therefore a technical regulation requiring firepatrols at intervals not exceeding half an hour was issued. This requirement came into on 1st June, 1990. As the firedetection was later improved by the use of smokedetectors, and as these have proved to be an effective early warning system, this regulation was later cancelled, and the intervals for the firepatrols are now back to normal, i.e. one hour.

Scandinavian Star was registered under Bahama flag and was not subject to inspection by the Danish authorities, before it went into service. As the investigation later proved, the ship was not fit and ready for service. The defects were not as much the condition of the ship, as they were the operational standards of the crew. A technical regulation requiring all foreign ships to be inspected and approved by the Danish Maritime Authority came into force 1st June, 1990. In practice the inspection is carried out as an extended port state control on the basis of the Paris Memorandum. The inspection focuses especially on the operational qualifications of the crew. The inspection is to a certain extent coordinated with the other Scandinavian countries. The inspection procedure is still under development.

The location of the bodies gave a clear indication that the behaviour of the passengers during the attempt to escape in many cases were not rational. It is believed that if the passengers had been more aware of the arrangement of the cabins in relation to the escape routes and how to perform when a fire broke out, it could have saved some of the

passengers. As has been mentioned before, some of the corridors had dead ends and signposts showing that the exit was 3 meters before the end of the corridor. This must have been very difficult to observe under the prevailing conditions. Also the warning system failed to wake up many of the passengers. Furthermore, the PA system failed to give instruction and guidance to the passengers, probably due to few announcements, if any, from the bridge or probably technical malfunction. After considering the problem, it became clear, that substantial safety gains could be obtained, if the passengers in such and similar disaster situations were more aware of how to behave in a rational way. In the spring of 1991 a prize dissertation was offered by the Danish Investment Foundation. The winning report came up with recommendations about how to instruct passengers and crew, if and when a dangerous situation was approaching. The report clearly stated that the need for information is often undervalued. One of the most interesting findings, concerning passengers' reaction, is that once having accepted the danger, only 25% act in a rational way, 60% await the initiative of others and the final 15% seem totally paralyzed by the situation. The often expected panic-reaction is normally not found.

The Danish minister for industry also instructed the Danish Maritime Authority, when sufficient knowledge was obtained, by all means to try to improve the relevant international instruments with regard to the safety against fire. In cooperation with Norway and the United States a proposal for amending SOLAS was submitted to the member countries in IMO. During the 60th meeting in the Maritime Safety Committee (MSC 60) in May 1990 a number of measures for existing passenger ships were adopted. Even if the date for fitting sprinkler system in ships constructed after 1980 (SOLAS 74) was not completely to the satisfaction of Denmark, the overall opinion is that the adopted measures will significantly improve the standard of fire protection in existing passenger ships. However, on one issue the Danish administration is not content. As was proved in this disaster, the calorific value of the surface material and the ability of this material to develop toxic smoke to a great extent in a fire, is far too

high. Knowing that material having much lower calorific values is available on the market both for the vertical surfaces and for the ceilings, Denmark submitted a proposal to the 61st meeting of MSC in December 1992 for amending the required maximum value (45 MJ/m2) in the SOLAS Convention. It was considered that, as a compromise, a value of 30 MJ/m2 could be agreed on. However, only one country supported Denmark in this proposal, and the matter was sent back to the relevant subcommittee for further consideration.

The legal aftermath.

The Danish Safety of Ships Act deals with the general duties and responsibilities of the involved parties.
The responsibility of the owner is to see that faults or defects, which may come to his knowledge are repaired and to ensure that the ship is subjected to the statutory surveys and is provided with valid certificate. Furthermore, it is the owner's obligation to ensure, that it is possible for the master to perform his duties. It is believed that responsibilities for the owner, as stated in this act, are uncommon in other countries. It was originally introduced into the Safety Act in 1980, because it was realized that the safety standard on board ships depended very much on the attitude shown by the owner. The purpose was also to give support to the master in carrying out his responsibilities.
The master's responsibility is to see that the ship is in a fit condition as regards safety.
The Safety Act is also applicable to foreign ships in Danish ports or in Danish territorial waters. The disaster itself took place in international waters, but at the official inquiry it was revealed that the munster list and emergency plans were not in accordance with the actual conditions on board the ship, and that no abandon ship and fire drill had been carried out before or after the ship had started to operate. On this basis charges were filed against the owners

and the master. On the 3rd December 1992 the verdict was given. The master was found guilty and given a penalty of 60 days' ordinary imprisonment. The two owners were found guilty and given a penalty of 40 days' ordinary imprisonment. Both the master, the owners and the prosecution have appealed to the high court concerning the penalties.
It may be of interest for you to know that the Safety Act is presently under review in the Danish Parliament, a majority in Parliament being of the opinion that punishment for offences of this type should be more severe than is the case presently under the act.

Conclusion:

Even if the circumstances for this disaster has been carefully investigated, and measures have now been taken to avoid similar disasters, the last word has not yet been spoken.

Questions about safety in passenger ships using Danish ports are still subject to debate in the media and in political circles. There are those, who are of the opinion that all foreign ships using Danish ports in every respect should bee subject to Danish regulations, also those regulations which are supplementary to the international conventions. The official opinion, however, is that the best way to improve the standard on board passenger vessels is to submit proposals and put forward arguments in IMO. The Danish Maritime administration is of the opinion that the question of regulations for technical standards and the regulations for qualifications of the crew is not the most urgent problem. The biggest and most important problem is the fact that it seems difficult for some countries to enforce the international conventions, which could be due to lack of ressources. Denmark pays great importance to the newly established IMO subcommittee, which has been given the task of dealing with flag state compliance. It is the hope that this initiative will promote safety in general and particularly in passenger vessels.

Lesson to be learned from

the Scandinavian Star Disaster of 7 April 1990

Danish Maritime Authority

LESSON 1

Arson in passenger ships is a serious risk why remedial measures need to be identified.

GENEREAL QUESTION ABOUT FIRE PROTECTION IN PASSENGER SHIPS

Ventilation; to what extent do stopping of the ventilation affect the survival of crew and passenger?

Firedoors; do the closing mechanism secure that doors close and remain closed during a fire?

Passenger behavior; how can passengers in a critical situation be influenced to behave rationally?

Operations control; how do persons in command monitor and contral the development of a fire?

THE CAUSE

- Low operational standard

- Ship not ready for the intended service

- Communication between crewmembers and between crew and passengers hindered by lack of a common language

- Low sound level of the alarms and the PA system

- Complicated arrangement of corridors in the accommodation for the passengers

- Difficult to locate and read the signposting

Signposting

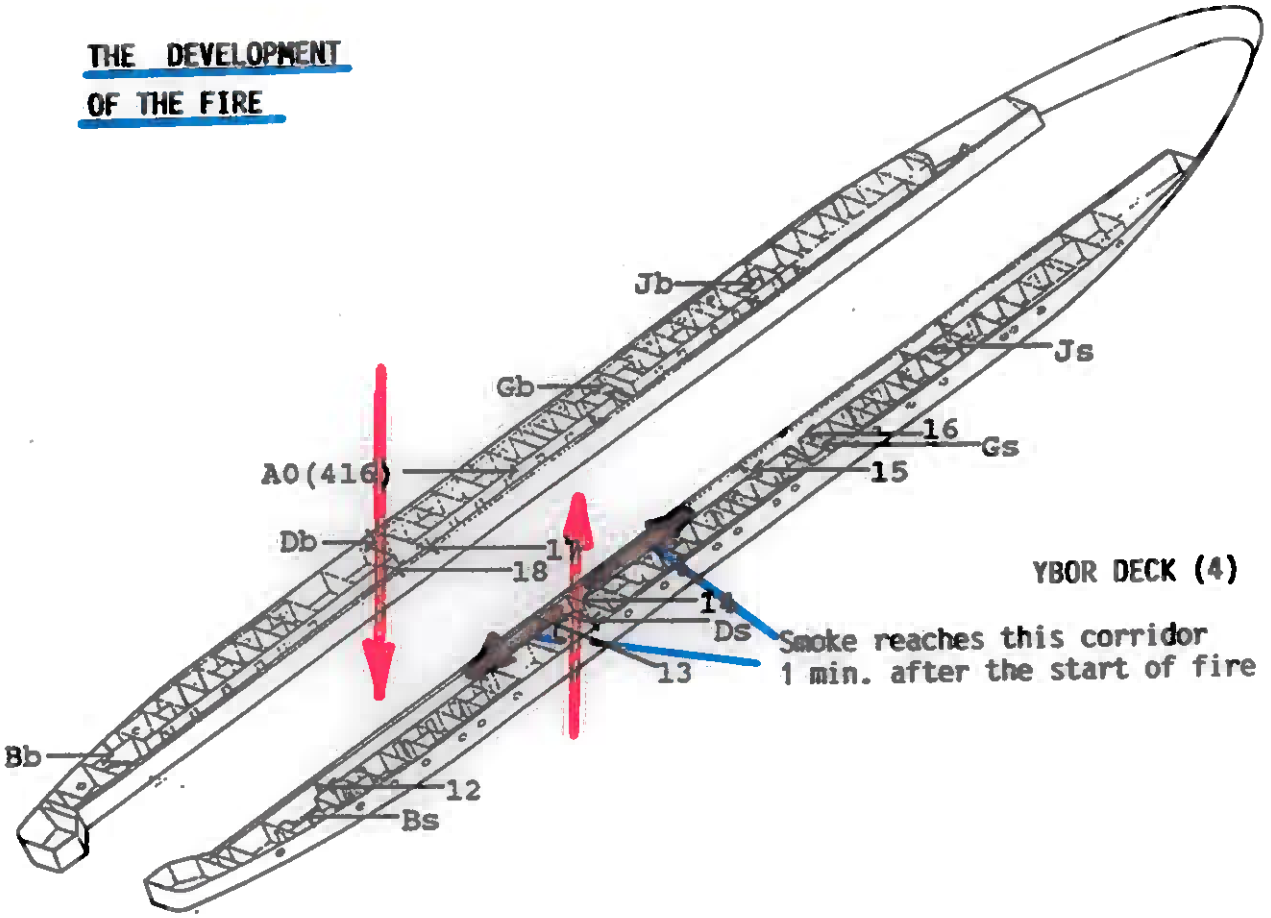
Note: Location of the signposting in the "smoke zone"

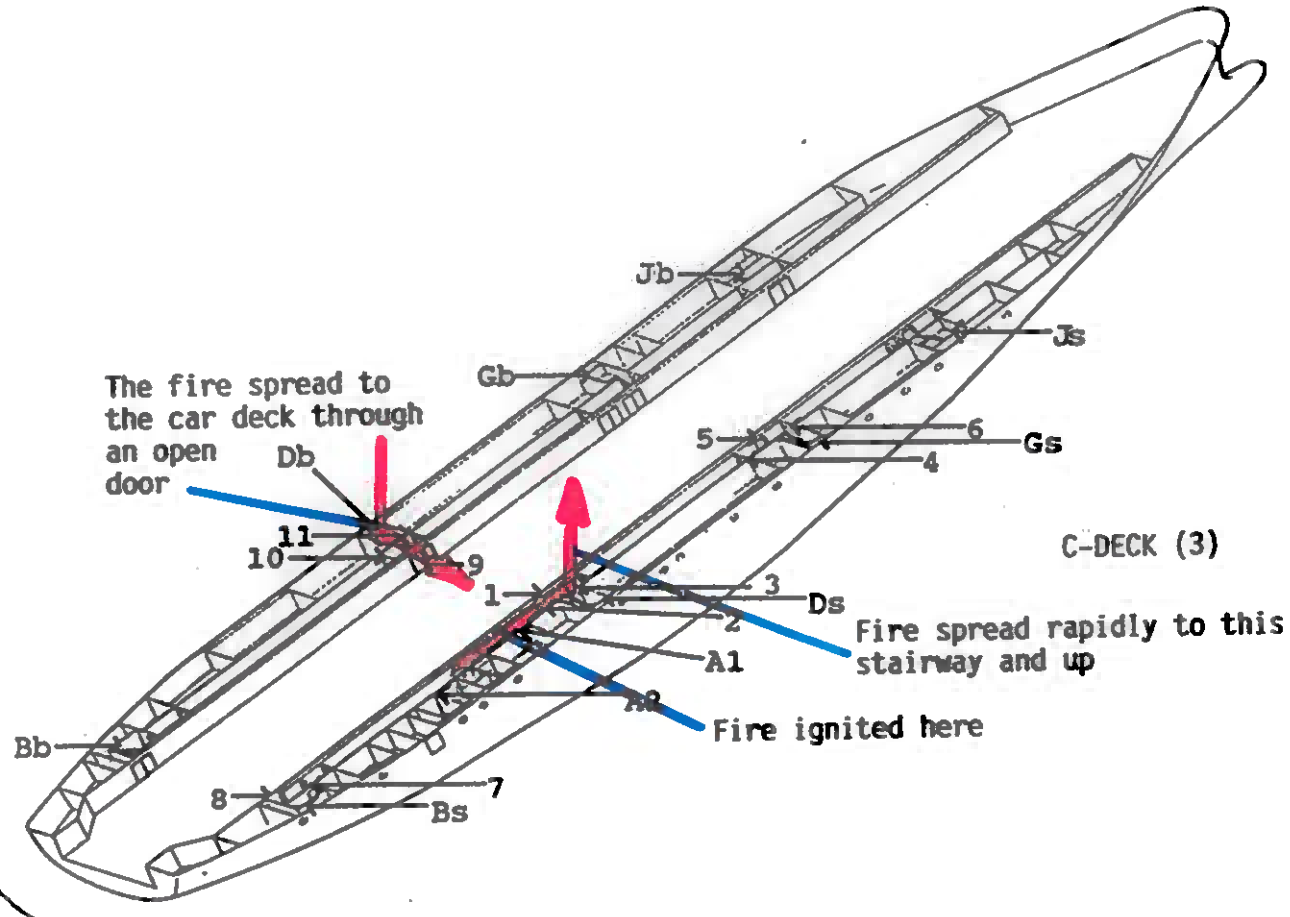
Signposting

Note: The language used is not appropriate. Should have been a "Scandinavian" language

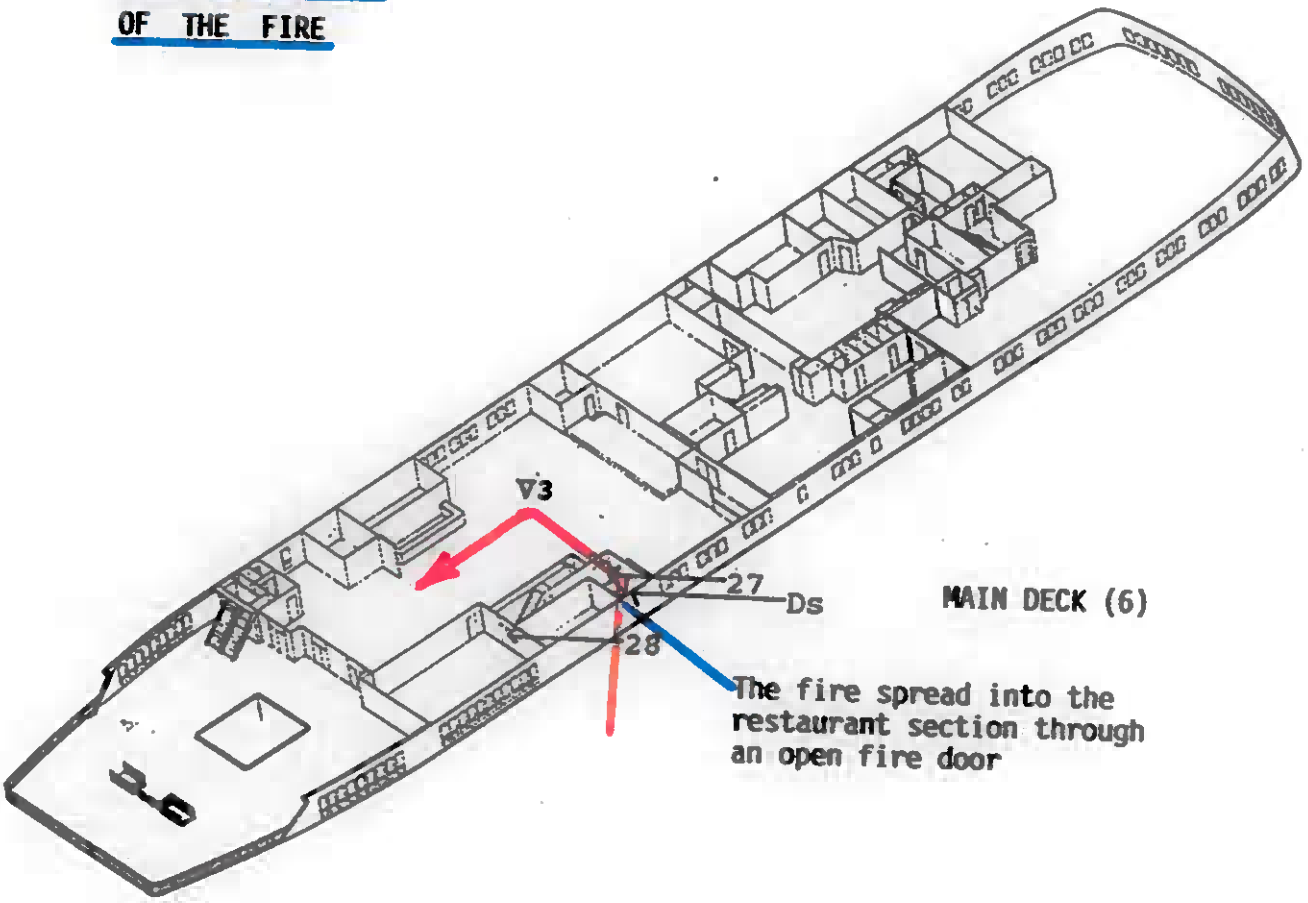
Note: Confusing message

THE DEVELOPMENT OF THE FIRE



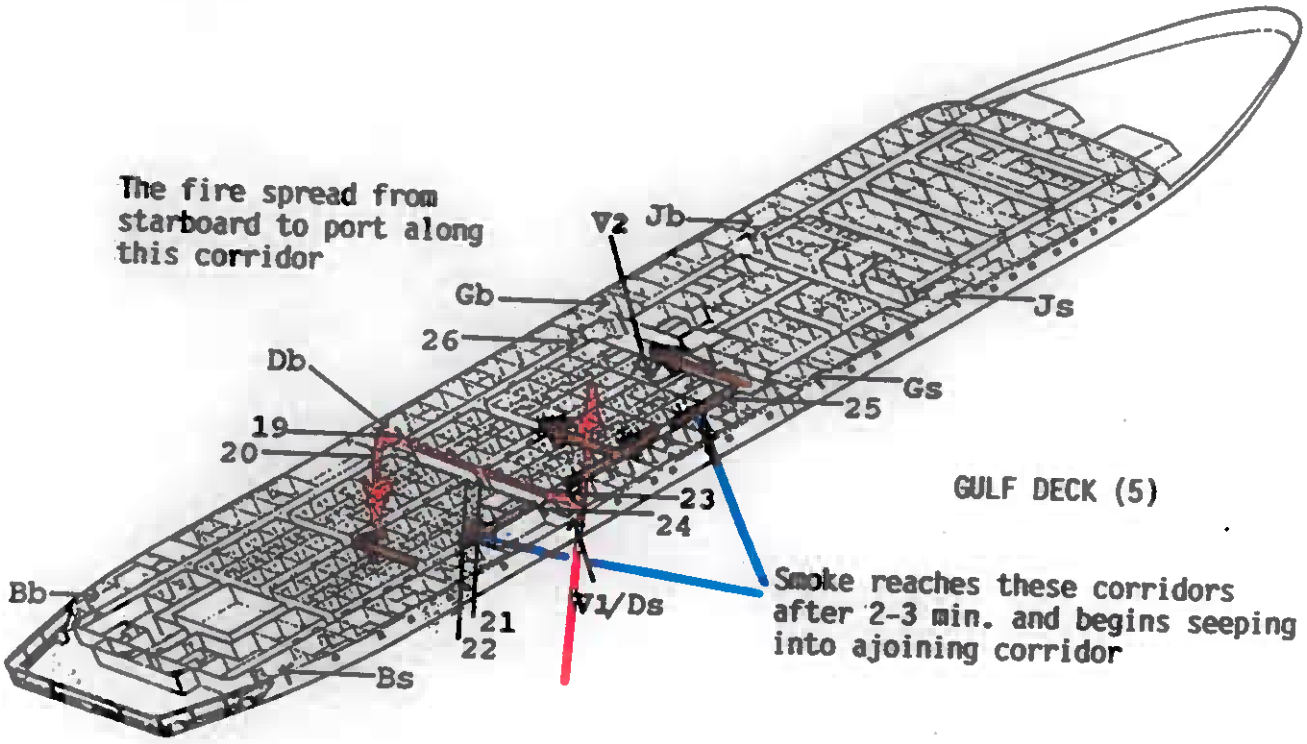


THE DEVELOPMENT OF THE FIRE



MAIN DECK (6)

The fire spread into the restaurant section through an open fire door



The fire spread from starboard to port along this corridor

GULF DECK (5)

Smoke reaches these corridors after 2-3 min. and begins seeping into ajoining corridor

LESSON 2

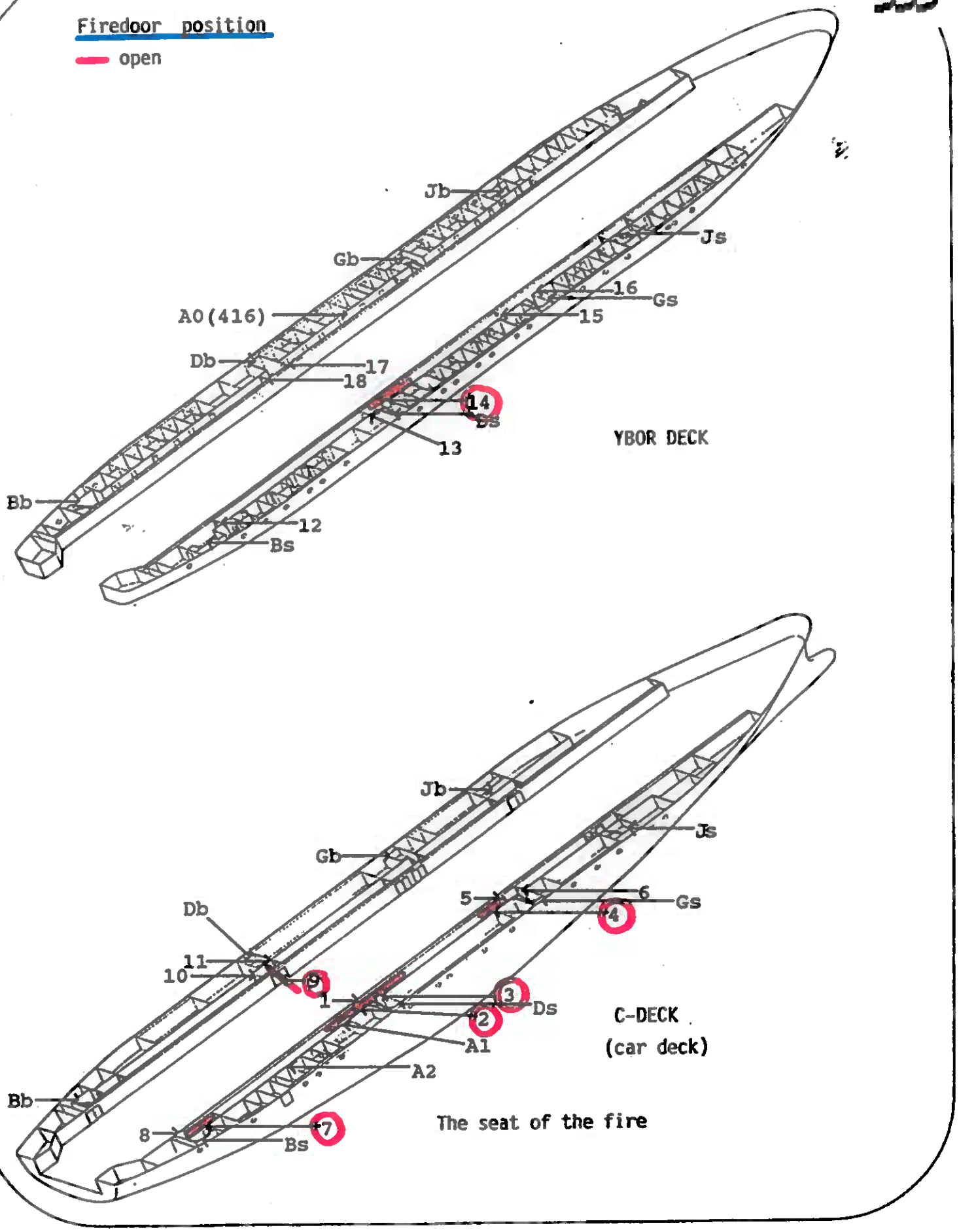
STRUCTURAL FIRE PROTECTION IN EXISTING PASSENGER SHIPS IS NOT SATISFACTORY

Staircase "Db", port side, from Ybor deck (4) downwards

LESSON 3

SMOKE - NOT HEAT - IS THE KILLER

Danish Maritime Authority


Firedoor position
open
Jb
Gb
A0(416)
Db
17
18
14
Ds
13
Bb
12
Bs
Js
16
Gs
15
YBOR DECK
Jb
Gb
Db
11
10
9
1
3
Ds
2
A1
A2
Bb
8
7
Bs
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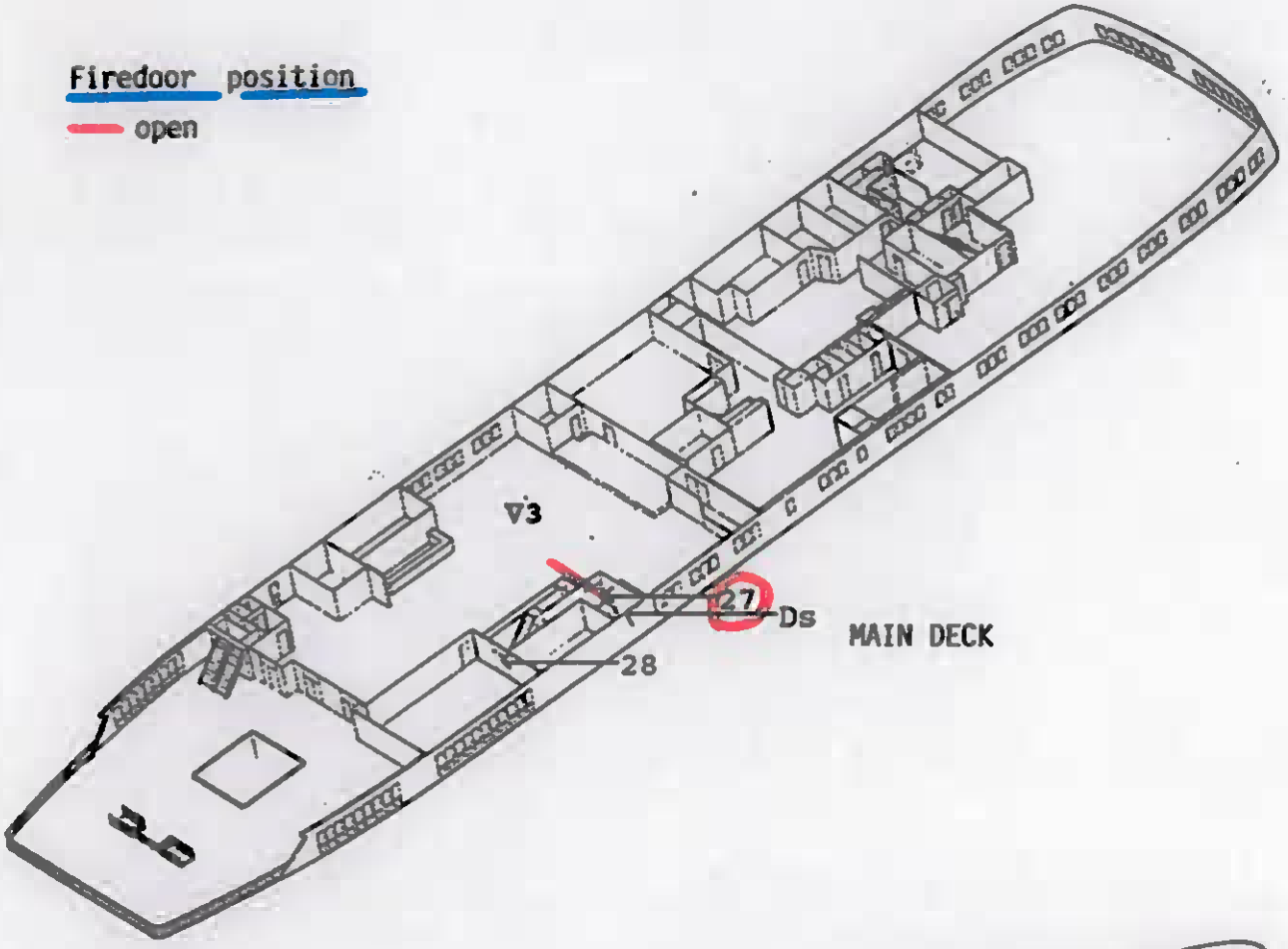
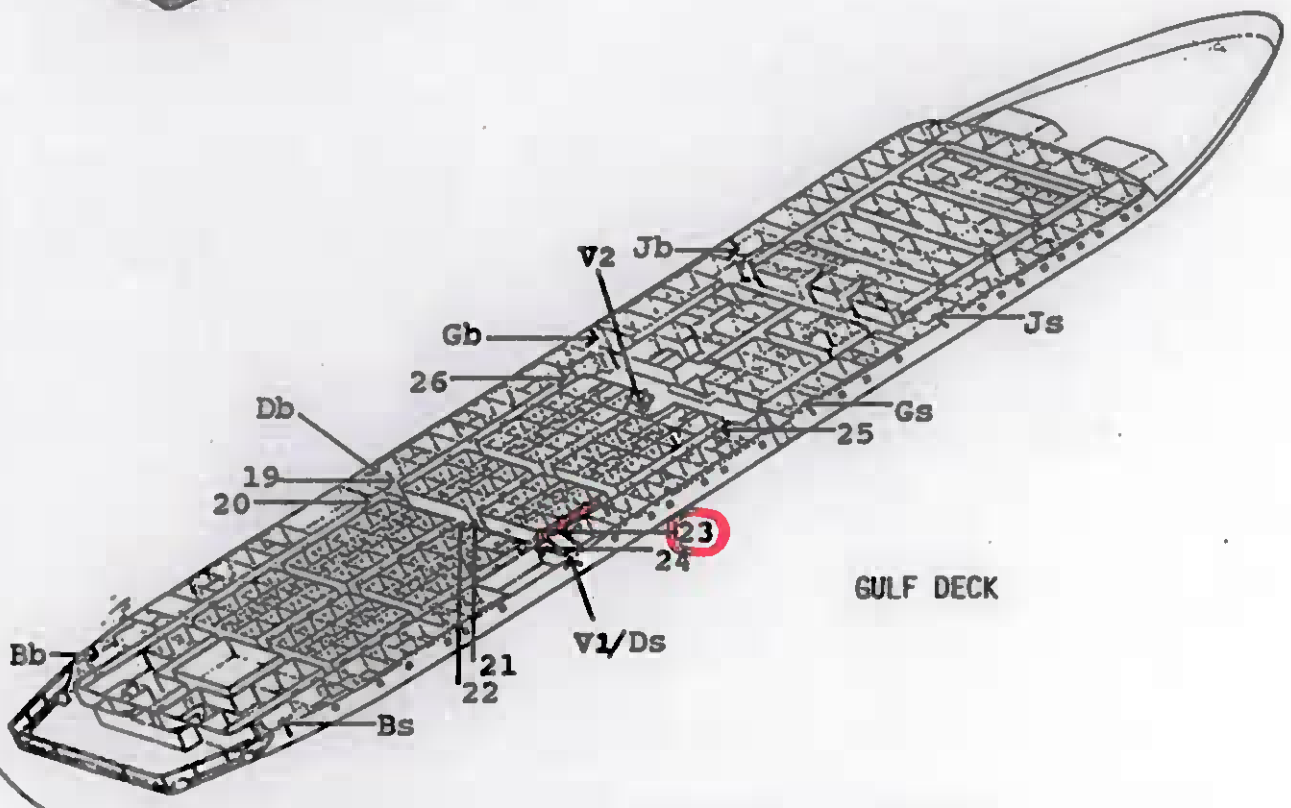
Gs
4
C-DECK
(car deck)
The seat of the fire

Firedoor position

open

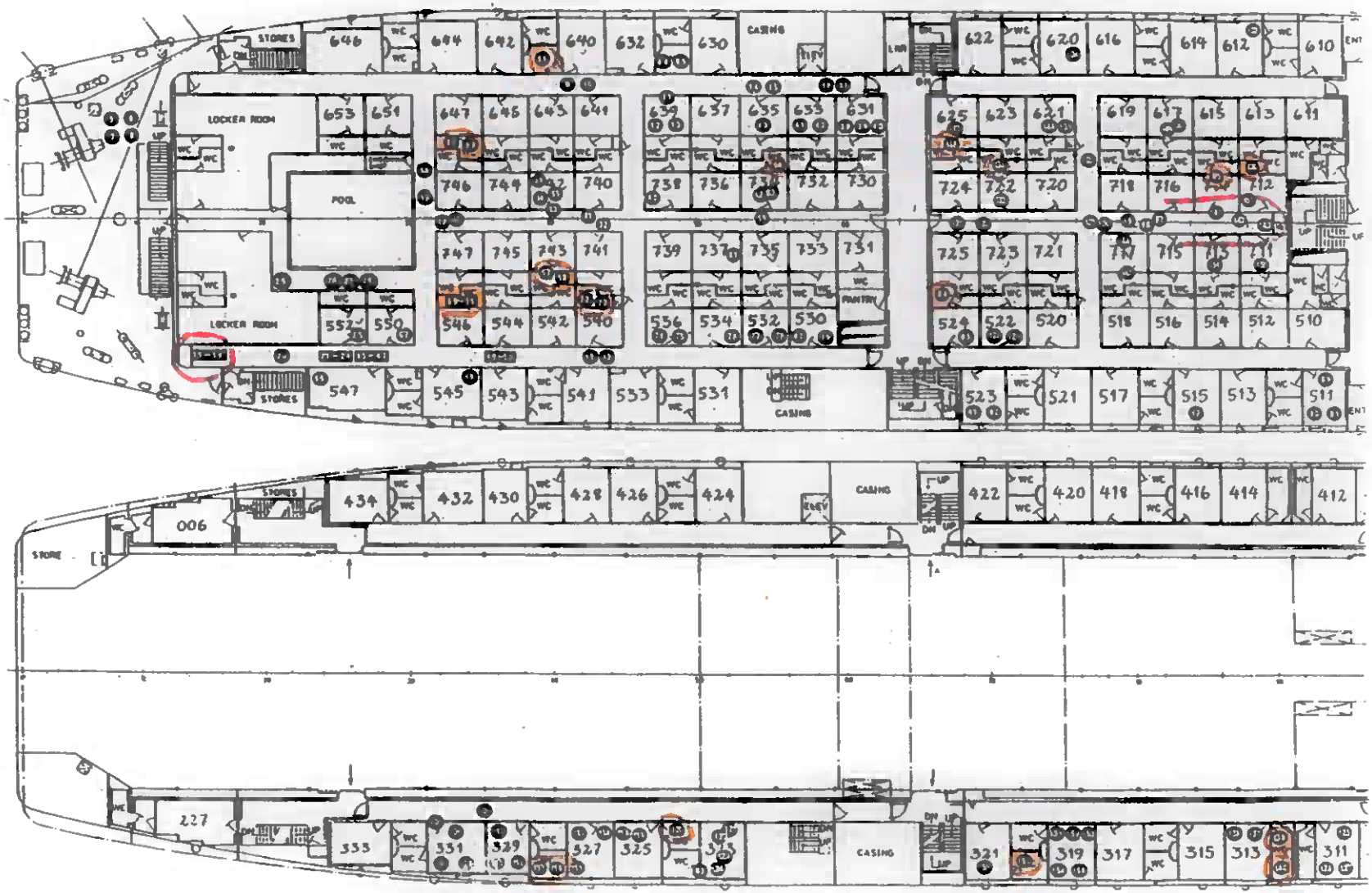




LESSON 4

FIREDOORS IS EFFECTIVE IN LIMITING THE SPREADING OF A FIRE, BUT THE CLOSING FUNCTION IS A CRITICAL FACTOR

WHERE THE BODIES WERE FOUND



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LESSON 5

MANY PASSENGERS IN A CRITICAL SITUATION DO NOT BEHAVE RATIONALLY, BUT PANIC IS NOT THE NORMAL REACTION

WHERE THE BODIES WERE FOUND

- 99 bodies in their cabins, of which
- 25 were in the bathrooms

- 50 bodies in the corridors, of which
- 20 were in dead-end corridors

LESSON 6

DEAD-END CORRIDORS ARE DANGEROUS

LESSON 7

THE FLAGSTATE CONTROL IS NOT ALWAYS A GUARANTEE FOR A SAFE SHIP

LESSON 8

SAFETY IN SHIPS ENGAGED ON INTERNATIONAL VOYAGES CAN ONLY BE OBTAINED THROUGH INTERNATIONAL COOPERATION

LESSON 9

THE ROLE OF THE OWNER IS OF GREAT IMPORTANCE WITH REGARD TO SAFETY ON BOARD SHIPS