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SUMMARY

The Australian registered motor tanker *Arthur Phillip* was on a voyage from the Saladin oil terminal, West Australia, to Botany Bay, New South Wales, with a full cargo of crude oil. At about 2325 (UTC +9 l/2), 5 May 1991, in approximate position 037 degrees 31 minutes South 132 degrees 59 minutes East, the fire alarm sounded and the bridge alarm panel indicated a fire in the accommodation block at main deck level. A fire was confirmed in the crew recreation room/bar. The Master altered course to bring the *Arthur Phillip* closer to another vessel, the *Alcides*, in the event that assistance may have been required.

The fire was reported to be extinguished by 2340 and the *Arthur Phillip* resumed course for Botany Bay. No person was killed or injured, though some affect of smoke inhalation was reported by certain members of the crew. The fire resulted in significant damage to the crew recreation room/bar.

Under the provisions of the Navigation (Marine Casualty) Regulations the Inspector of Marine Accidents undertook an investigation to identify the circumstances in which the fire occurred and to determine its cause.

SCOPE OF THE REPORT

The fundamental purpose of investigating any marine accident is to determine its circumstances and the causes with the aim of improving safety of life at sea and the avoidance of accidents in the future. It is not the purpose to apportion liability, nor, except so far as is necessary to achieve the fundamental purpose, to apportion blame.

PERSONS INTERVIEWED

On 10 & 11 and 23 & 24 May 1991 *from the Arthur Phillip:*

Captain Richard Hoare	Master
Warwick Mason	1st Mate
Gregory Jones	Junior 1st Mate
Richard Rothery	2nd Mate
Douglas Craig	Chief Engineer
Brett Lesmond	4th Engineer
Jerry Roberts	Bosun
Peter Macraild	AB
Dennis Wright	AB
Timothy Gammell	Ordinary Seaman
Noel Doull	Crew Attendant
Paul Robinson	Pumpman
Peter Avraam	Pumpman/Donkeyman
Earl Cork-Woods	Chief Steward
William McKee	Chief Cook
Phillip Littlejohn	2nd Cook

On 17 MAY 1991

Christopher James Hoger	Able Seaman

On 18 MAY 1991

Roger John Pitts	Able Seaman
Steven Anthony Cannon	Able Seaman (Bosun's Mate)
Christopher James Hoger	Pumpman/Donkeyman

The following were also consulted:

Mr PR Donoghue MlFE	ACT Fire Brigade
Forensic Document Services	Queanbeyan NSW
Division of Building and Constrnction, CSIRO	Melbourne

TIME - ADVANCING THE CLOCKS

Whilst in West Australian waters, the *Arthur Phillip* had maintained West Australian Standard Time, UTC +8 hours. As the vessel proceeded east, so the clocks aboard the vessel were adjusted for local standard time.

On the night of 5/6 May the ship's clocks were adjusted by one hour to bring ship's time from UTC +9 to UTC +10 (Australian Eastern Standard Time), This was done in two stages, the clocks were moved forward half an hour at 2200 ship's time and again at 0200 ship's time 6 May 1991. Hence the period 1730 to 2330 spans five and a half hours, not six.

It is normal practice for the crew, however, for convenience, to advance the time by one hour at some time during the evening. The fire alarm was logged on the bridge at 2325 (UTC +9 1/2) approximately.

The times for the purposes of this report are given in local ship's time as shown by the bridge clock.

SEQUENCE OF EVENTS

Introduction

The Australian registered motor tanker *Arthur Phillip* (call sign VJAP, Lloyds number 7343516) was built in 1974 at the Whyalla Ship Building and Engineering Works, South Australia. The vessel is a little over 239 metres in length and has a summer deadweight of 65,103 tonnes. Inert gas was fitted in 1986 and the vessel was fitted for crude oil washing. On 5 May 1991 the inert gas was reported to be in proper working order and in operation.

The engine room and all accommodation is situated aft, aft of frame 52. The ship is powered by a seven cylinder Sulzer diesel engine developing 14,392 kW giving a top speed in the region of 15 knots. The *Arthur Phillip's* hull and machinery is classed with Lloyds Classification Society and is permitted to operate with an unmanned machinery space.

The accommodation housing consists of six decks, the uppermost being the navigation bridge deck; the upper bridge deck, containing the deck officers' accommodation; the bridge deck, containing the engineer officers' accommodation; the saloon deck, with the officers' recreation room/bar and saloon together with the stewards' accommodation; the boat deck containing deck and engine room ratings accommodation; and the upper (or main deck) containing the galley, crew utility spaces, including the recreation room/ bar area.

On Sunday 5 May 1991 the *Arthur Phillip* was in the eastern part of the Great Australian Bight on a voyage from the Saladin Terminal, off Thevenard Island West Australia, to Botany Bay. The vessel was loaded with a full cargo of crude oil.

At about 2325, in approximate position 037 degrees 31 minutes South 132 degrees 59 minutes East (about 200 miles south west of Kangaroo Island) the fire alarm sounded on the bridge and the alarm indicator panels indicated a fire at the main deck level in the accommodation block. A fire was confirmed in the crew recreation room/bar.

The crew recreation room/bar is a space of approximately 9.5 metres by 4.8 metres, situated on the forward outboard port side of the main deck accommodation, between frame spaces 46 and 52. It is reached from the cross alleyway at main deck level, which also serves the hospital, linen stores, crew TV room, messroom and laundry, and provides access to the decks above.

Access to the recreation room/bar is through a wood panel door which, instead of a "kick" panel in the lower portion to allow emergency access, has a 400mm X SOOmm steel mesh grill on each side of the door, the mesh being a diamond shape of 20mm X lSmm.The bulkhead, except where it was common with the pumproom, and deckhead are not required to be fire rated (Marine Orders, Part 15.56 -Ship Fire Protection, Fire Detection and Fire Extinction-) and are sheathed in fire resistant panelling. The bulkhead by way of the pumproom and the deck, which is common to the engine room deckhead, are constructed to "A 60" fire rating. The deck was covered in a wool carpet.

Furniture in the area consisted of two occasional tables, bar stools and easy chairs of wood and foam construction covered in cloth fabric. All port-holes are permanently closed and cannot be opened. The ventilation is by an air conditioning duct in the deck head close to the bar.

The bar itself was '3" shaped (Attachment 2), constructed of wood and faced with simulated padded leather of "buttoned" vinyl and polyurethane foam. Behind the bar were shelves to contain glasses. Two plastic containers of nuts were kept on the middle shelf, and a plastic bottle of methylated spirits used for cleaning audio equipment was kept on the bottom shelf. The bar had three fridges, one small "bar" fridge for keeping eatables, and two of approximately 1.4 cu metres, one for beer and the other mainly for soft drinks.

The recreation room contained no dedicated portable fire fighting equipment and it was not required to do so. The nearest extinguisher was a dry chemical extinguisher in the alleyway, adjacent to the electrical locker and dirty linen store. A fire hose locker, containing an 18 metre canvas hose 62mm in diameter, was located between the crew laundry and mess room. The recreation room area was protected by two heat sensors located in the deckhead, one situated above the bar itself, and the other at the outboard end of the space.

According to the ratings the room is used by the deck ratings and others during "smoko". To clean hands and to provide protection of the furniture from dirty overalls a number of rolls of paper towelling were normally kept on the bar counter nearest the entrance door. The Master stated that, to his knowledge, the mess room was used for this purpose, not the recreation room. Both the Master and Mate stated that they had never seen paper towelling in the bar area.

For the purposes of this report the description of the incident is divided into three stages:
the circumstances leading to the fire;
fighting the fire; and,
the clean up.

Circumstances Leading to the Fire

The birthdays of two crew members, Steven Anthony Cannon and Christopher James Hoger, were due to fall in the week commencing 5 May, Mr Cannon's on 6 May and Mr Hoger's on 8 May. It was decided, apparently on the initiative of Mr Cannon, that the two of them would buy a case of beer between them and share it with other crew members as a celebration. At least two other crew members, Roger John Pitts and Christopher John Gregus, were included in the planned "party".

Because of accounting difficulties beer, the only alcoholic beverage sold through the crew bar, was sold only in quantities of half or full cases. The chairman of the bar committee, the Pumpman Paul Robinson and his deputy Roger Pitts, held the keys to the beer locker. When issuing a quantity of beer the purchase would normally be entered onto a loose leaf writing pad and subsequently entered into the bar record/account book. Both the loose leaf pad and bar record book were kept on the bar counter.

The *Arthur Phillip,* in common with other Australian ships, is operated on a two crew system, one crew being on leave while the other is on "swing".

Mr Cannon, an Able Seaman (AB) and engaged as the Bosun's Mate, joined the *Arthur Phillip* on 18 April 1991 and this was his first "swing" on board. He had however served on other tankers including the Australian Sky. Mr Hoger, AB, joined the *Arthur Phillip* in November 1990 and was on his third "swing". Mr Pitts AB (who has also completed an integrated

ratings course), joined the *Arthur Phillip,* in June 1986 and had been a regular crew member since that time . Mr Gregus, Pumpman/Donkeyman, had been a regular crew member since June 1987.

As of Saturday evening all four of the above individuals were on "day work" duties and were not involved in watchkeeping. Hence on Sunday 5 May they had no duties and were not required for routine work until 0700 Monday 6 May.

On Sunday afternoon at about 1500 (UTC +9) Mr Pitts decided to make two banners from the paper towel rolls kept on the bar counter, one proclaiming "Happy Birthday Pugsey" and the other "Happy Birthday Chris". These banners were estimated to be 2 to 3 metres each in length and were fixed to the bar surrounds at deck head level, above the thwartships section and inboard fore and aft section of the bar, respectively.

A case of Victorian bitter (24 X 375 ml stubbies, alcohol content 4.9%) was purchased from the bar stock sometime during the afternoon and before the evening meal the four individuals stated that they had either one or two beers from the case.

After tea, at about 1730, the four crew members stated that they had returned to the bar to share drinks from the case throughout the evening. They variously played darts, competing in a variety of games, and left the bar area from time to time to wash and dry clothes and, later in the evening, to find food from the galley.

Other crew members joined them from time to time. The Bosun, Pumpman and Ordinary Seaman all at some time or another went to the bar and were given beer from the "birthday" case. From their individual statements it would appear that these three would have accounted for at least 6 of the 24 stubbies purchased by Mr Cannon and Mr Hoger. One other crew member joined in the conversation but did not partake of alcohol. By 2100 Messrs Cannon, Hoger, Pitts and Gregus were left alone at the bar. At about this time the group finished playing darts and, gathering by the bar, engaged in small talk.

The air conditioning vent into the bar created a noticeable local draught. At some time during the evening the banners above the bar had become partially detached and fell across the front of the bar. According to the statements of the four men present the banners were torn down to stop them hanging over the bar and left on the deck of the recreation room/bar.

Throughout the evening the vessel was rolling noticeably in a moderate to rough sea and moderate swell.

Messrs Cannon, Hoger and Gregus were smoking, Mr Pitts was a non smoker. Both Cannon and Hoger were heavy smokers, and both were smoking almost continuously throughout the evening. Messrs Cannon and Hoger used matches to light their cigarettes, while Mr Hoger used a lighter for at least some of the time, which he recalls as having been on the bar at the outset of the evening. There were three or four ash trays on the bar counter and a further two on the occasional table behind where they were standing at the bar.

At 2200 the ship's tune was advanced by 30 minutes and the ship's time became UTC +9 l/2.

The four crew members stated that at about 2230 Mr Cannon went to the end of the bar nearest the door and started to tear off pieces of paper towel from the rolls and threw them at

his companions as though the towelling pieces were streamers. Messrs Hoger, Pitts and Gregus stated that they virtually ignored Mr Cannon and the paper towelling, and they brushed off any of the towelling landing on them. Mr Cannon, it is stated, stopped throwing the towelling when he failed to obtain any positive reaction from the other three.

Shortly after the paper throwing incident Mr Gregus stated that he went to the ship's galley to find something to eat, either something left over from the evening meal or something for a sandwich. He also stated that as a "bit of fun" he took some paper towelling from the recreation room/bar deck to tie around some of the galley equipment in order to gain some reaction from the Second Cook. This was done in good humour and was meant, without malice, as a practical joke. However, he was not able to tie the paper as planned as it tore as he attempted to tie knots, so he left the paper on the deck in the galley area.

At about 2330 Mr Pitts stated that he detected a smell of burning and alerted the other three. They state that the paper towelling had caught fire behind them and they immediately attempted to stamp out the flames. The fire apparently spread to the angle of the bar, which apparently had the effect of a "chimney", causing the vinyl covered, polyurethane foam facing on the bar to ignite. The fire, and associated smoke and fumes, spread rapidly forcing Messrs Cannon, Pitts and Gregus from the room. Initially Mr Hoger remained in the bar area attempting to beat out the flames with a towelling bar runner, until, very shortly after, he was also forced from the room.

The four men maintain that they did not sound the fire alarm because the incident developed so fast and by the time the first three had evacuated the room the fire alarms were already sounding. Cannon stated that he went to look for a fire extinguisher.

At this time Mr Dennis Wright, AB, (12-4 watchkeeping rating) was on his way from his cabin, one deck above the crew recreation room, to the crew mess room to make a cup of coffee before going on watch. As he descended the stairs he saw Messrs Cannon, Pitts and Gregus running from the mess room and saw flames in the bar. They said that "it just went up". Mr Wright could not recall whether the alarms were sounding. He went immediately to the phone in the mess room to phone the bridge, but the line was dead. He tried a second time and when the line still appeared to be dead he went back to the alleyway. By this time there was a lot of smoke and it appeared that a degree of panic had taken hold. Mr Wright helped Mr Pitts and Mr Gregus deploy the hose from the locker in the cross alleyway outside the crew mess room. They found the hose difficult to connect up. According to Mr Wright they were unable to fit the jet nozzle, the hose was too long and formed at least eight kinks which could restrict the water flow. By this time the smoke had become very thick and they had to get down as low as possible to deck level to breath. When the hydrant was opened there was no water on the fire main.

When it was discovered that no water was available on the fire main Mr Gregus went to the steering flat at the after end of the ship and started the emergency fire pump and returned to the recreation room. Meanwhile Mr Wright left Mr Pitts with the hose and made his way to the open deck where he stated that he suffered a fit of dry retching from the smoke and fumes.

Fighting the Fire

The events and movement of people between the time that the fire alarm sounded and the muster of the crew at sometime after 2340 has been reconstructed from all statements taken. There were some differences of detail in the accounts given by the ship's staff.

On 5 May the Chief Mate was on watch on the bridge from 2000 to 2400. At about 2325 the fire alarm sounded and the bridge alarm panel indicated a fire in the accommodation on the main deck level. Within a very short space of time the Second Mate, who had been working in the ship's office before going on watch at midnight, arrived on the bridge closely followed by the Junior First Mate and the Master. All officers were equipped with torches and UHF radios. When the fire alarm sounded the duty engineer, the Fourth Engineer, went straight to the engine room and in accordance with normal procedures immediately started the fire and general service pump.

Upon arriving on the bridge the Master assumed command of the emergency. The Chief Mate instructed the Junior First and Second Mates to locate the seat of the fire and they proceeded via the internal stair well, quickly checking each of the four intermediate decks for signs of smoke as they went. The Master instructed the Chief Mate to also go below, find the seat of the fire and report back. The Master was joined by the Third Mate and the Radio Officer. The Master switched on the engine room intercom and confirmed that water was available on the fire main. A west bound vessel, the Bermudian tanker *Alcides,* was contacted and informed of the emergency and the *Arthur Phillip* altered course to close the *Alcides* should assistance be required.

The Second Mate and Junior Mate met an AB, who was ordered to get the self contained breathing apparatus ready. When they reached the head of the stairway, inside the accommodation, between the boat deck and the upper deck they saw smoke coming from the stairwell. Some of the ratings were gathered there and told the officers that the fire was below. The Second Mate immediately continued on down the stairs to find where the fire was and to determine its extent. The Junior First Mate remained at the head of the stairs and was very soon joined by the Chief Mate, who continued down the internal stair to the upper deck.

The Second Mate stated that he discovered the fire in the crew recreation room. According to the Second Mate the door to the recreation room was open and he could see flames inside reaching to deckhead level. He found one crew member at the end of the hose and another trying to remove the kinks. They told him that the hose was ready, but no water was available. He stated that he called for water on his radio and immediately went to the emergency locker to prepare the self contained breathing apparatus sets. He did not close the recreation room door.

Shortly after the Second Mate leaving the alleyway, water came on to the fire main. One of the three seamen had by this time closed the door and water from the open ended hose was directed through the grill in the lower half of the door by Mr Cannon assisted by Messrs Gregus and Pitts, who were lying or kneeling on the deck below the smoke level.

At this time the Chief Mate arrived and ordered the men to vacate the area. The three men were apparently slow to comprehend the order but eventually retreated to the crew messroom and the open deck on the starboard side. When the Chief Mate arrived the door was closed and he could see no flames, but the level of smoke was apparently increasing. The Chief Mate

returned by the internal stair to theJunior First Mate and instructed him to prepare breathing apparatus and then returned to the upper deck. At this time somebody turned the water supply to the hoses off at the hydrant.

Shortly after the Chief Mate returned, the Chief Engineer and Mr Hoger, wearing breathing apparatus, entered the cross alleyway from the port open deck.

The Chief Engineer was awakened by the fire alarms. He dressed and as he left his cabin on the bridge deck he was able to smell smoke. He went out to the open deck and proceeded towards the engine room. When he was satisfied that the fire was not in the engine room he went to the steering flat, where he found the emergency fire pump was running. He then went to the air conditioning room where he found the Second Engineer closing down the accommodation ventilation system. From there he went to the emergency locker situated on the port side of the main deck just aft of the entry door to the accommodation, where he found a number of crew members, including Mr Hoger. He and Mr Hoger donned the breathing apparatus, entered the accommodation on the port side, followed by the Fourth Engineer, who had also donned breathing apparatus, as a back up.

On entering the alleyway the Chief Engineer noted that a significant quantity of water was swilling about the alleyway, which was full of smoke, and that two hoses run out in the alleyway were both turned off. The Chief Engineer attempted to use a hose with a jet nozzle to effect an entry into the recreation room, but found that the pressure was too great to control the direction of the jet, and that the hose was very heavy and difficult to drag. Reverting to the open ended hose he directed water on to the recreation room door and surrounds to cool the entrance. The Chief Engineer, keeping low, slowly opened the door. The time lapse between the alarm sounding and the entry into the recreation room by the Chief Engineer in breathing apparatus, was approximately ten minutes. Upon entering he detected no great heat escaping from the room and although the room was full of smoke and fumes could see no flames and detected only a small area of smouldering poiyrethane foam, which was doused in water. The water to the hose was then stopped. The smoke and fumes restricted visibility to about 600mm and with the aid of a powerful torch the Chief Engineer then proceeded to search the space for personnel. No casualty was located and a subsequent muster of crew accounted for all personnel aboard.

At 2340 the Chief Mate reported that the fire was under control. The Master resumed course, thanking the *Alcides* for their assistance.

Once the officers were satisfied that the fire was apparently extinguished in the recreation room, adjoining spaces were inspected to check for a possible spread of the fire. When the area had been ventilated and cleared of smoke and fumes sections of panelling within the recreation room and the adjoining TV room were removed to ensure that the fire had not spread and no embers remained.

The seat of the fire was apparently at the corner of the bar adjacent to where Mr Hoger was standing. Much of the bar facing was destroyed and much of the room was affected by extensive heat and smoke damage. The deckhead was badly scorched and the plastic light covers had melted and fallen to the deck. The plastic nut containers, kept on the middle shelf behind the bar, were warped out of shape, as was the bottle of methylated spirits on the bottom shelf.

The Clean Up

In the Master's presence the Chief Mate gave orders that the recreation room should not be touched and that cleaning the area should be confined to the alleyway. The bosun stated that he could not recall such a specific instruction.

The Chief Mate also stated that he was concerned to secure the bar book, but in the event he did not take it into safe keeping.

Crew members commenced to clean up the area, using portable air driven "salvage" pumps, mops and buckets to remove the salt water from the alleyway and crew recreation room areas.

It was at this time that particular notice was taken of a quantity of unravelled paper towelling lying around and the quantity of bottles in the plastic rubbish bin. The paper towelling was seen by the Chief Mate, the Junior First Mate and the Master. These witnesses described it as a large quantity. Paper towelling in the galley area was described as stretching from the forward galley door, through the galley space and into the after store areas to the after door and back, which would account for a length of at least 40 metres of paper towelling in that area. The Junior First Mate went through the galley area with the Chief Steward some time after the fire, the Junior First Mate's recollection was of an extensive amount of paper, the Chief Steward however was unable to comment on this matter.

The rubbish bin, which immediately after the fire was used to keep the recreation door open, was variously described as being two thirds full to full. The most frequent description was full to about 10 centimetres from the top.

At about 0130 the Master and Chief Mate interviewed the four men. Initially the Master interviewed Messrs Cannon, Pitts and Gregus. He stated that, disregarding the condition of their eyes following the fire, their general behaviour and the smell of beer on their breath led both he and the Chief Mate to form the conclusion that the men were under the influence of alcohol. Following this interview he went to interview Mr Hoger who was helping with the pumps used to clear the water from the accommodation deck. He came to the conclusion that he too was under the influence of alcohol, but apparently to a lesser degree than the other three. Certain statements were recorded as having been made by one of the individuals, in particular one to the effect that the four had been wrapping each other in paper towelling.

The Master made an entry in the official log book recording the circumstances of the fire and stating that in his opinion Messrs Cannon, Pitts and Gregus were heavily under the influence of alcohol, and to a lesser degree so too was Mr Hoger.

Whatever the understanding of the Chief Mate's instruction with regard to leaving the recreation room as it was, the crew members did, in part at least, remove the rubbish and clear debris from the deck. At some time in the early morning, when Messrs Cannon, Gregus, Pitts and Hoger were assisting with the clean up, Mr Pitts stated that he saw that the bottle holding the methylated spirits was warped from the heat. When he lifted it from the rack behind the bar it was seen to be leaking. He states that he gave the leaking bottle to somebody for disposal, and he recalled this as being the Bosun or the Pumpman. Mr Gregus stated that he saw somebody, whom he thought was Mr Cannon, struggling out with the rubbish bin and so he took one side and assisted in emptying it at the ship's side. Mr Cannon denied that it was he that helped empty the bin.

The bar record book evidently remained on the bar until about 1300 on 6 May when it was delivered to the Master. Captain Hoare stated that he had noticed that some pages had apparently been removed. Later examination of the book revealed that a number of pages had been removed, and the last recorded entry was shown as 4 April.

The *Arthur Phillip* arrived in Botany Bay on 10 May. Messrs Hoger, Pitts, Gregus and Cannon signed a statement effectively disclaiming the Master's original log book entry, stating that their observed condition was attributable to the fire and fumes.

C O M M E N T

The Conditions in the crew recreation room on the evening of 5 May 1991 contained the three elements required to start and maintain a fire, oxygen, fuel and a source of ignition.

Oxygen

The recreation room was ventilated by air from the air conditioning system, which under any circumstances would support combustion. The evidence was that there was a noticeable movement of air from the air conditioning inlet. This draught was such that the paper banners fixed to the bar by Mr Pitts became partially detached.

Fuel

The paper from the rolls of paper towelling kept on the bar provided the material for the paper banners displayed over the bar. By 2330 these banners had been torn down and were lying on the deck, variously described as being behind and in front of the four seamen at the bar. These banners were supplemented by the towelling thrown by Mr Cannon between half an hour to one hour before the fire started.

There is a conflict in evidence regarding the practice of keeping paper towelling in the crew recreation room. The Master and Mate both stated that they had not seen packets of towelling in the room, while the four seamen stated that rolls of towelling were kept there to protect the furniture. What ever the situation towelling was strewn not only in the recreation room but also in the galley and galley store room area.

There is also a conflict of evidence regarding the amount of paper towelling that was strewn on the deck, both in the recreation room and in the galley and galley service areas. The two banners with the birthday messages were said to be 2 to 3 metres each in length. This is consistent with the size of the bar. Mr Cannon admitted to throwing pieces of towelling as streamers, but claimed that the total amount thrown was not great. The entry made by the Master and counter signed by the Mate of 6 May 1991, that Messrs Hoger, Pitts, Cannon and Gregus had wrapped one another in towelling was refuted by the four men in a typed statement submitted to the Mercantile Marine Superintendent on 10 May, in Botany Bay and also at interview.

It is not possible to determine how much paper towelling was thrown (each roll contains 100 metres) and the amount of paper on the deck at the out break of the fire cannot be assessed. However the paper towelling on the deck provided an ample source of material susceptible to easy ignition.

Mr Gregus admitted to taking towelling into the galley but again stated that it was a limited amount. Statements from the Master and two officers suggest that in the order of 40 mea-es was found in the galley area and service area containing the four ship’s freezer stores for meat, vegetables, dairy produce and the beer store. While the towelling in the galley area has no direct relation to the fire in the recreation room it could indicate that the four men understated the amount of towelling strewn around.

From photographs taken on 10 May 1991 there is evidence of light scorching of the carpet around the occasional table and between the table and the bar area, apparently from the initial ignition of the paper and suggesting that the paper fire was not intense.

From observation and photographs the deep burning and charing in the inboard angle of the bar would suggest that either there was considerable combustible material, such as paper, already in the corner or the melting ignited foam fell to the deck at that point, or a combination of the two.

The point of ignition of the vinyl padding was at the inboard angle of the bar close to where Mr Gregus was standing. Photographs show that the right angle the bar formed at this point apparently created a “chimney” effect which burned the bar padding in a deep “V” shape and destroyed much of the padded rail. Objects on the deck are clearly outlined by unscorched carpet,such as the bar stools, which protected the area beneath them. Once the vinyl covering of the bar front was breached the polyurethane presented a highly combustible and volatile source of material to rapidly raise the fire’s temperature, with the added characteristics of generating thick black toxic smoke and fumes.

The presence of the paper together with the padding created a high risk environment for fire.

Chairs and other furnishings as well as a bottle of methylated spirits were present in the recreation room, while these materials did not catch fire, they did provide a further potential source of fuel.

The carpet of wool offered a low flame spread surface. The remaining surfaces, the deck head and bulkheads were of fire resistant materials. The deck and bulkhead by way of the pumproom were appropriately fire rated.

Source of Ignition

There were a number of possible sources of ignition in the recreation room, including electrical appliances and cables.

In this case the source of ignition was at deck level adjacent to the four men standing at the bar, well removed from any possible source of ignition other than a cigarette or match. Three of the seamen, Messrs Hoger, Cannon and Gregus were smokers using matches (or the lighter used by Mr Gregus) to light their cigarettes and also using ashtrays on the bar and on the occasional table close to the bar. It is most probable that the source of ignition was from either a match or cigarette.

It is possible that the fire was started from a match falling from the bar. Given, however, the description of the events given by the four men at the bar, it is more probable that a discarded cigarette, left in an ashtray on the occasional table, was dislodged with the rolling of the ship and/or burnt down so that it overbalanced and fell into the paper towelling on the deck.

This is supported by a report from an officer of the Australian Capital Territory Fire Brigade who examined the photographs on behalf of the Inspector. He considered that the account given by the four seamen was quite consistent with the starting of such a fire. He also added that given the type of fuel and circumstances surrounding the event the fire would have been much worse if it had burnt out of control for just a few more minutes.

The responsibility for the presence of the paper towelling on the deck, although falling on all four present in that no attempts were made to clear it up, rests mainly with Mr Cannon, who threw the “streamers”, and with whoever pulled down the birthday greeting banners and discarded them on the deck.

The responsibility for the source of the ignition rests with the three smokers, Messrs Hoger, Cannon and Gregus, on the basis that a discarded or forgotten cigarette or match caused the towelling to catch fire.

CSIRO Experiments

In order to establish how the fire may have started the CSIRO Division of Building, Construction and Engineering carried out a series of experiments to test the ignition of the paper towelling and the vinyl coated polyurethane foam bar cladding (Attachment 4). The experiments were carried out in accordance with the Standards Association of Australia, Furniture- Assessment of the Ignitability of Upholstered Furniture, Part 1 (Ignition source - Smouldering Cigarette. AS 3744.1- 1989) and Part 2 (Ignition Source - Match-flame equivalent. AS 3744.2 - 1989).

Eleven experiments were conducted from which it could be concluded that:

- both loosely crumpled and folded layers of paper towelling may be ignited by a cigarette and undergo sustained smouldering;

- lengths of paper towelling, both loosely crumpled and folded in layers, after sustained smouldering may undergo a transition to flaming when affected by a change in air flow patterns;

- flaming paper towelling, loosely crumpled and placed in a comer made by two vertical bar panels is sufficient to ignite the vinyl coated fabric and the polyurethane foam, which will then burn until completely consumed.

The CSIRO tests also demonstrated that under the right conditions the paper could flame afier smouldering for some significant time; under the experimental conditions for at least 17 minutes.

The experiments also showed that the vinyl cladding was resistant to ignition and would not continue to flame if the source of ignition was withdrawn. The polyurethane foam, however, ignited immediately with a vigorous flame and resulting dense black smoke. Polyurethane foam comes in many grades and densities, with and without fire retardant additives. It is not known whether the foam in the crew recreation room was supposed to have fire retardant characteristics, but it would appear that if it had any such properties they had little affect.

Contributory Factors

This investigation is unable to determine the amount of alcohol consumed by Messrs Gregus, Pitts, Cannon and Hoger. The Inspector finds it difficult to accept at face value the statements of the four men that they consumed between four and six bottles (including drinks before tea)

in the five and a half hour period up to 2330. The actions of both Gregus and Cannon as noted by the Master and Chief Officer and in their behaviour with the towelling would suggest that they had consumed sufficient alcohol to alter normal conduct.

It may be that they purchased only one case between them, but if as was stated other members of the crew also shared as many as six bottles from the case, leaving eighteen bottles for Messrs Gregus, Pitts, Hoger and Cannon, they would have had equal shares of four and a half bottles each. However they all declared having consumed five or six bottles each. It is noted that some of the paper towelling was strewn around in the galley area extended into and store room area where the beer locker is located and that Mr Pitts held a key for that locker. Mr Pitts, however, was adamant that he did not obtain further beer supplies from the locker that evening.

No documentary records of the beer purchases remained, the relevant pages having been ripped from the bar account book. The bar accounts book was kept by the bar committee chairman and his deputy, Mr Pitts. Mr Pitts stated that his normal practice was to enter the previous day's bar sales in the accounts book every morning and that he recalled entering the sales for Saturday (4 May) on the Sunday. The bar accounts were therefore up to date as of the morning of 5 May. At sometime after midday 5 May a number of pages had been removed showing the latest entry as 4 April.

It is not known who removed the pages or what the motive was for doing so other than to destroy evidence of the sales/consumption of beer. Tests were carried out in an attempt to detect any writing imprinted on the remaining pages of the bar book, however no significant writing was detected. It is not possible therefore to establish either what beer had been bought, or by whom, in the preceding days and what, if any, recent purchases any of the four individuals may have made, which may have supplemented the "birthday" case. The Master stated that he noticed the pages were missing when handed the book at about 1200 6 May.

Most of the empty beer bottles discarded on 5 May were put into the recreation room's rubbish bin, which was emptied on the morning of 6 May. Certain wimesses who saw the bin immediately after the fire variously described it as being 2/3, 3/4 full and being full to within 1Ocm of the rim. The rubbish bin, a plastic bin, 530 mm in depth by 450 mm in diametre and so loaded would contain around 60, 0.375 litre stubbie bottles or about two and a half cases. It is not known when the bin was last emptied but normal practice was for the bin to be emptied every morning. The bin would almost certainly contain bottles and cans, including soft drink cans, from before lunch and tea of 5 May in addition to any bottles consumed by the four men.

The bin was not secured after the fire and Mr Gregus was quite open about the fact that he had helped carry the bin out of the accommodation after the fire and emptied the contents. While he stated that he helped Mr Cannon empty the bin, Mr Cannon denies that he emptied the bin and none of the other crew members, who are known to have helped clear up, remember emptying the bin.

The Master, Chief Mate and Junior First Mate all separately formed the view that the four men had been drinking and their behaviour was that of persons under the influence of alcohol. Mr Mason, the Chief Mate, stated that when he arrived at the fire he moved Messers Cannon, Pitts and Gregus as the area was quickly becoming filled with smoke. On hearing the slurred speech and their apparently uncoordinated behaviour he was concerned for their safety and formed the definite view that the men were under the influence of alcohol. At interview

Mr Mason pointed out that he too was exposed to the smoke and fumes and suseptable to the same level of shock, but was not similarly affected. Both the Master and Chief Mate stated that they could detect a strong smell of beer on the breath of the four men.

According to advice from the ACT Firebrigade and the scientist, who conducted the fire tests all the materials burning in the recreation room would have given off carbon monoxide, while the polyurethane foam and vinyl would produce hydrogen cyanide, nitrogen oxides and hydrogen chloride. The four men were all exposed to the smoke from when the fire started and it is possible, therefore, that their exaggerated behaviour (slurred speech and the reported difficulty of Mr Cannon to stand) could have been, at least in part, as a result of shock from the fire, coupled with the effect of the fumes.

Fire Fighting

The Chief Engineer stated that apart from residual smouldering the fire was extinguished when he entered the room. This is supported by the lack of heat he felt, in that he could stand without discomfort. It would appear therefore that all but some residual smouldering material was extinguished by the open ended hose played by Messrs Cannon Gregus and Pitts through the grating in the lower part of the door.

According to the four men involved the alarms started to sound as they were vacating the room having failed to stamp out the burning paper. There was no extinguisher kept in the bar area, being a relatively low risk area. The nearest extinguisher, bright red in colour and a dry powder type, was about 3.5 metres from the recreation room door adjacent to the electrical locker and dirty linen store. No attempt was made by any of the four men involved to secure the extinguisher at the initial stages of the fire when the towelling was seen to be alight.

Nor was any immediate attempt made to sound the fire alarm, which was situated in the cross alleyway about 3 metres from the recreation room door. It was reported that the small metal hammer which should have been hanging by the alarm was missing, although this was not the cause of the alarm not being used.

The four men stated that it all happened so fast that there was little time to respond. However it is evident from interviews that Messrs Greg-us, Hoger and Cannon were not aware of the fire extinguisher, and indeed by the time they abandoned the recreation room the fire had caught the polurethane foam and was probably past extinguishing by a dry powder appliance. By this time also the alarms had been activated by the heat sensors in the deckhead of the recreation room. In any event they stated that their priority was to secure a hose.

It is also evident that the 18 metre 62millimetre hose was too large, too long and difficult to handle. The Chief Engineer reported that when trying to use the hose with the nozzle on, he was unable to control the jet of water, the pressure being too great. The hose was of an approved type for shipboard use and met the basic statutory requirements for fire fighting equipment. However under Australian legislation smaller, more easily handled hoses are permitted for accommodation areas.

A trial of an open ended hose on board the *Arthur Phillip,* demonstrated that the water trajectory and force was more than sufficient to reach the recreation room bar and forward bulkhead from the doorway.

Shipboard Procedures

Had the fire not been all but extinguished by Gregus, Pitts and Cannon the situation had the potential to have deteriorated very rapidly. Advice from the fire brigade was that the room temperature would have risen to 1000 degrees centigrade within three minutes. Given this temperature it would have taken little time to spread to the soft furnishings and into the TV room with its chairs and tables.

According to statements the first reaction of a number of the ship's crew when the fire alarm sounded was to leave their cabin to see what was going on. Some then returned to their cabin to put on appropriate clothing, while others attempted to assist in fighting the fire, whether appropriately clothed or not.

The sounding of the fire alarm did not bring into operation the *Arthur Phillip's* emergency muster organisation. The provisions of Marine Orders, Part 29 (Emergency Procedures and Safety of Navigation), stipulates that there shall be two distinctive emergency signals only, the emergency stations muster signal and the abandon ship signal. The continuous ringing of the fire alarm, although obviously an alarm, does not conform to the emergency signal of at least seven short blasts followed by a prolonged blast.

In a submission Captain Hoare pointed out that the fire alarm signal did not require the crew to muster at their emergency stations. On the *Arthur Phillip* the sounding of the fire alarm is an indication to the responsible officer that a heat or or smoke sensor or fire button had been activated, thereafter the fire is located and appropriate action taken, which may include the sounding of the General Alarm. The general ringing of the fire alarm, activated automatically, alerts the crew to the extent that they may anticipate the general alarm. The Master was satisfied that this procedure was followed and the fire extinguished. He went on to point out that had the initial measures been unsuccessful, then the general alarm would have been sounded, the ship's crew would have regrouped at the remote muster station and a renewed response initiated.

While the fire was successfully extinguished and the ship's procedure was apparently followed, all deck officers and senior engineer officers were initially involved at or near the scene of the fire or on the bridge. Some of the crew members had become involved in a response to the fire, while others stood around in the accommodation, apparently with little purpose. The question is raised whether the shipboard procedures were fully understood by all the crew.

Had the fire initially been more extensive or had it spread beyond the bounds of the recreation room, there would have been a significant time delay before the ship's crew could be organised to respond. There was also prevailing opinion amongst some of the officers that, despite emergency drills, in the event of a real emergency they (the officers) would have to deal with it themselves.

According to the *Arthur Phillip's* official log book, boat and fire drills were undertaken once each month, in accordance with Marine Orders, Part 29 (Emergency Procedures and Safety of Navigation). The fire and emergency drill component of the drill was stated to run for about one hour, on a monthly basis, with the purpose of acquainting the crew with the use of the ship's equipment.

The Inspector would question the effectiveness of these shipboard procedures, and the ability of an effective regrouping of the crew in the event of the emergency signal being sounded.

CONCLUSION

1. The fire in the crew recreation room/bar aboard the *Arthur Phillip* was most probably caused by a discarded cigarette falling from the occasional table into paper towelling on the deck.

2. The responsibility for the presence of the towelling and the associated fire hazard rests, in varying degrees, with Messrs Cannon, Pitts, Hoger,and Gregus.

3. The responsibility for the source of ignition rests with the three smokers, Messers Cannon, Hoger and Gregus.

4. There is no evidence that the fire was in any way the result of a deliberate or malicious act.

5. There is no direct evidence that drugs or alcohol were a contributing factor. However the Inspector, in considering the issue of the paper towelling, the destruction of the bar records (by persons unknown), the admitted actions of Messrs Gregus and Cannon and the reports from the Master and Officers considers that more beer was consumed than was admitted to and alcohol must be considered a contributor factor in the fire.

6. The fire was effectively extinguished by the initial attack on the fire by Messrs Cannon, Pitts and Gregus, when directing the hose through the recreation room door grill.

7. The Chief Engineer, Mr Craig, assisted by Mr Hoger and supported by Fourth Engineer, Mr Lesmond, extinguished residual smouldering material.

8. The shipboard procedures were followed, however, the Inspector does not believe that the procedures reflect the optimum response, or that they are appropriate for contemporary shipping.

9. The fire hose sited in the accommodation conformed to the statutory requirements, however the length and diameter of the hose were unsuitable for fighting an accommodation fire.

A N N E X

Under the provisions of sub-regulations 16 (3) and (4) of the Navigation (Marine Casualty) Regulations, drafts of the report were sent to those who may be affected by the publication of the report and submissions were received by or on behalf of the Messers Hoger Pitts Cannon and Gregus; the Caltex Tanker Co (Australia) Ltd; the Chief Mate; and the Master.

Submission on behalf of Messrs Hoger, Pitts, Cannon and Gregus

A submission on behalf of the four seamen disputed the length of the galley and galley store room area.

The submission also referred to page 12 of the report which refers to the removal of the pages from the bar record book and the inability to establish" ....what. if any, recent purchases any of the four individuals may have made, which may have supplemented the “birthday” case.”

The four men deny categorically that they had anything to do with the destruction of the bar account record.

They also submitted that there was no motive for them to destroy the bar record book as that day’s purchase would not have been entered in the the book up to the time of the fire. Also, in relation to an attempt at concealing beer previously purchased it was submitted that there is no logical reason for the men to do so, there being no daily ration and they could purchase as much beer as they liked. Furthermore, it was submitted, it is not probable that they would have bothered to purchase beer in advance of the day that they intended to consume it.

The submission acknowledged that the report states that the bar book was available for anybody to tamper with from the time of the fire to 1200 on 6 May.

Inspector’s Comment

The dimensions of the galley and store area were checked. The Inspector is satisfied that, based on the various statements concerning the paper towelling in the area, the length of paper quoted should stand.

As stated in the report, the bar record book was submitted to forensic examination and no evidence was forthcoming from either the examination, or any other element of the investigation process, to establish who was responsible for the removal of the pages. The examination also failed to show any imprinted writing that could indicate any records of beer purchased.

Whatever the intent of the four individuals involved, the Inspector is satisfied that more beer was consumed by them than was admitted to and that, from their own account, the “birthday” case would not realistically account for all the beer consumed. It was noted on a visit to the ship that beer was readily available to crew members to take and keep in their cabins. The Inspector was unable to establish either, how much beer, if any, was readily available to the men from supplies they may have purchased in the preceding days, or an indication of the individuals normal consumption.

Submission on Behalf of Caltex

A submission on behalf of Caltex raised the following issues;

a) the report did not sufficiently emphasise the evidence of intoxication, based on reports to the company by the Master;

b) the fact that the fire apparently arose out of a breach of Section 99 of the Navigation Act and a breach of the Code of Conduct for the Australian Merchant Navy;

c) at page 13 in considering the possible effects of the smoke and fumes on the four men the Inspector expressed a medical opinion which he was not qualified to make;

d) the fire hoses kept in the accommodation met the Australian Maritime Safety Authority requirements.

Inspector's Comment

a) The Inspector notes the comment, but considers that, based on the evidence available and the comment on pages 11 to 13, the conclusions are fair and reasonable.

b) Action under Section 99 of the Navigation Act 1912 would lead to criminal charges, outside the procedures of a casualty investigation.

c) The Inspector canvassed the possible effects of the smoke and fumes, based on information from approved Merchant Navy fire courses, discussions with qualified fire officers and information from scientists involved in fire investigation. The Inspector considers that the possibilities expressed are reasonable.

d) The fire hoses kept in the accommodation at main deck level met the basic Australian requirements. However the relevant Marine Orders do allow for smaller gauge hoses to a minimum of 38mm diametre rather than the 62 mm hoses in use, and for shorter lengths of hose.

Submission by the Chief Mate

In respect of the emergency organisation Mr Mason submitted that all the deck officers were under his direction from the outset and the engineer officers responded correctly. The responsible people were in position and "at the ready" had the fire continued. He also submitted that the first aid was prompt.

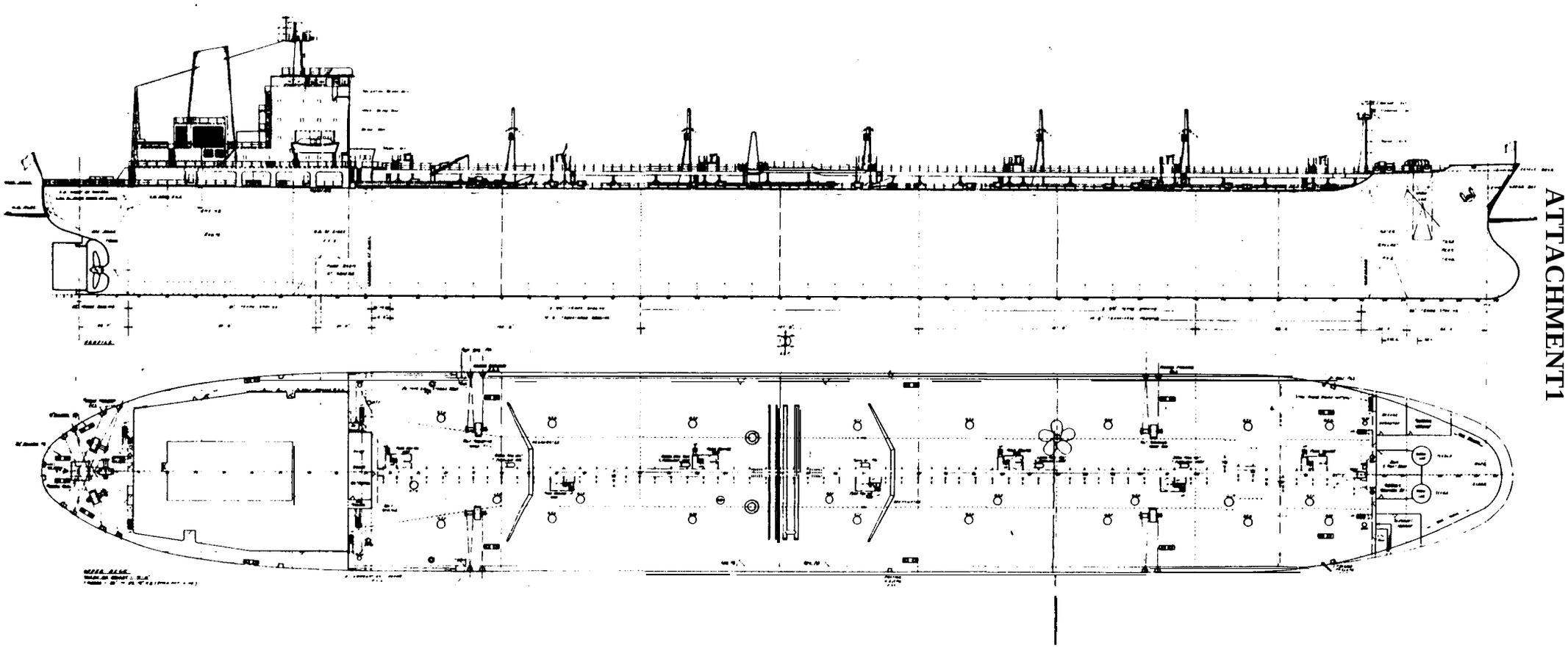
Inspector's comment

The inspector accepts that the response to the fire was in accordance with the shipboard procedures.

Submission by the Master

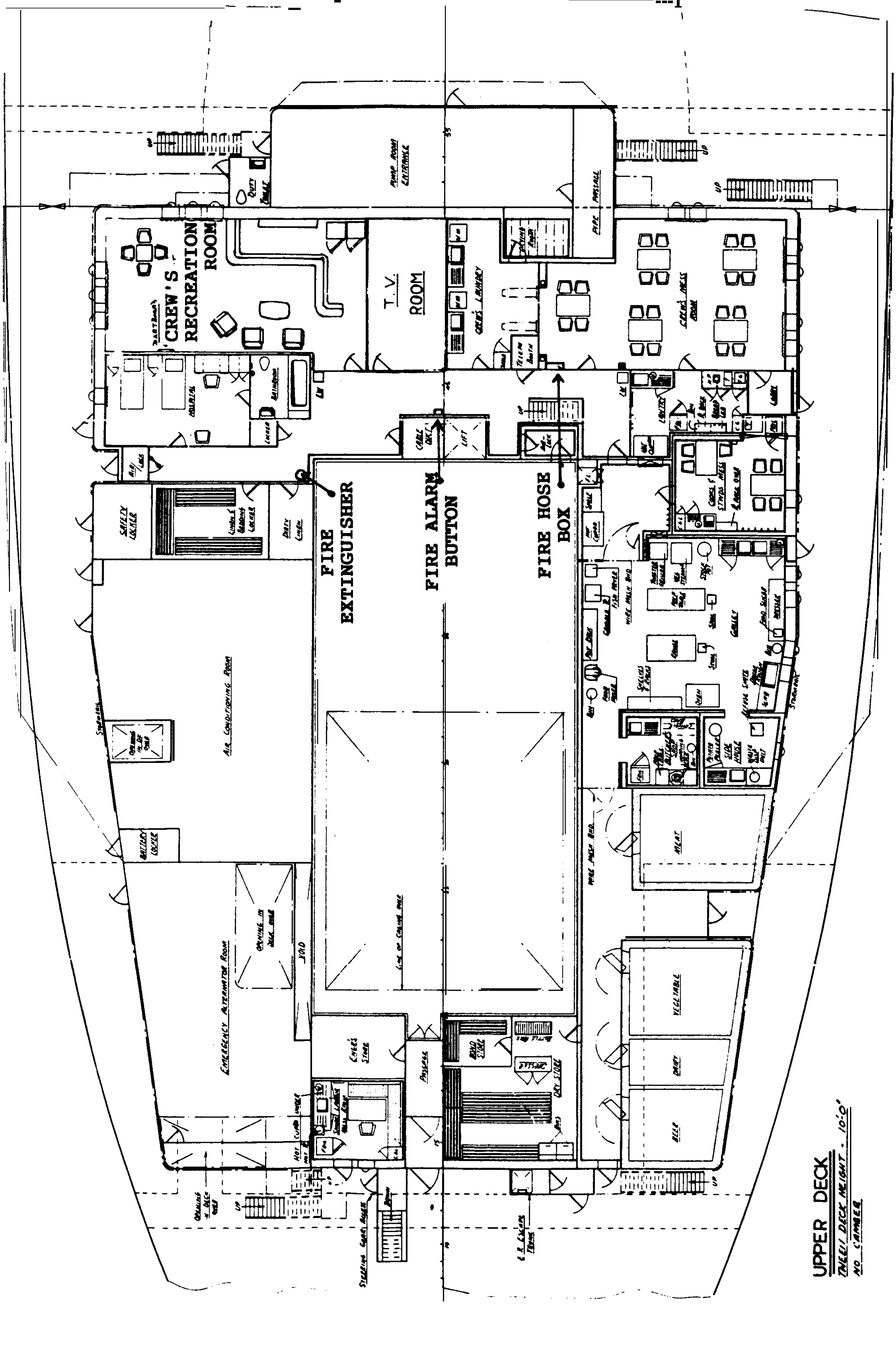
Captain Hoare made submission on points relevant to the emergency response organisation aboard the *Arthur Phillip.* The Inspector accepted the thrust of his submission and amended the report accordingly.

ATTACHMENT1



GENERAL ARRANGEMENT PLAN

ATTACHMENT 2



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SOUTH AUSTRALIA

INTERNATIONAL

CHART SERIES

SOUTHERN OCEAN

AUSTRALIA, SOUTH COAST

1:3 sooooo (22°30')

DEPTHS IN METRES

HEIGHTS IN METRES

MERCATOR PROJECTION

POSITION OF THE *ARTHUR PHILLIP* AT THE TIME OF THE FIRE

VICTORIA

MELBOURNE

ATTACHMENT 3

ATTACHMENT 4

AN INVESTIGATION INTO THE FIRE BEHAVIOUR OF PAPER TOWELLING AND A BAR FIXTURE

V.P. Dowling

CONFIDENTIAL

DBCE Doc 91/89 (M)

CSIRO DIVISION OF BUILDING CONSTRUCTION AND ENGINEERING

AN INVESTIGATION INTO THE FIRE BEHAVIOUR OF PAPER TOWELLING AND A BAR FIXTURE

V.P. Dowling

Report to Department of Transport and Communications

CONFIDENTIAL

DBCE Dot 91/89 (M)

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1. INTRODUCTION

Following a shipboard fire, the Department of Transport and Communications, through the Australian Maritime Safety Authority (AMSA), Southern Region, requested CSIRO to conduct a series of fire experiments. The questions to which they desired answers were:

(1) Can paper towelling, of the type believed to have been present at the fire, be ignited by a cigarette?

(2) Will any such ignition result in flaming of the paper towel?

(3) Can bar fixture panels of the type believed to have been present at the fire be ignited by flaming paper towel?

A series of experiments were devised to answer these questions, using ignition sources such as cigarettes and small flames that are specified for use in assessment of the fire performance of upholstered furniture.

2. SPECIMENS

The specimens, supplied by AMSA were:

(i) A complete roll of paper towel manufactured by Kimberly-Clarke Australia and described as 'Kleenex Deluxe Roll Towel, 83.8 m x 19 cm'.

(ii) 2 pieces of bar fixture panel, each 1 m x 750 mm, comprising 13 mm plywood over which was fixed 25 mm polyurethane foam covered by a vinyl coated fabric. The fabric and foam were fixed to the plywood by studs at 375 mm intervals, with more frequent placement of studs at the top and bottom edges. No information on the fire properties of these materials was supplied

3. IGNITION SOURCES

The ignition sources used were:

(a) smouldering; a cigarette conforming with AS 3744 (Ref 1). This standard requires a non-filter cigarette. 'Senior Service', was the make used for these experiments. The requirements for the ignition source are fully detailed in AS 3744 (Ref 1).

(b) flaming;

(i) Match-flame equivalent, as described in AS 3744. This standard requires a butane flame. The butane is supplied at 45 ml/min and 2.8 kPa through a tube of internal diameter 6.5 mm. The flame is applied for 20 seconds. The ignition source is fully detailed in the standard.

(ii) Match. The matches used were 'Redheads' brand Safety Matches.

4. CONDITIONING

The bar fixture panels, paper towelling and cigarettes were conditioned at a temperature of 20 +/- 2°C and a relative humidity of 65 +/- 5% for over 7 days immediately prior to the experiment. These conditions are commonly used for preparing building material specimens for fire tests, and are one of three alternative sets of conditions specified in AS 3744 (Ref 1).

5. EXPERIMENTAL PROCEDURE

The experiments performed are listed in Table 1. The experiments were performed in a room 4.2 x 3.3 x 2.4 m high (Figure 1). Experiments 1-7 and 9-11 were conducted with the door of the room open. For Experiment 8 the door was closed. The room was vented via an exhaust duct at a rate of one room air change every thtee minutes for all experiments. For Experiment 8, when the door was closed, air entered the room through an inlet duct near floor level.

In the ignition experiments on 4 metre lengths (as suggested by AMSA) of paper towelling (Experiments l-7) the paper towelling was placed in the centre of the junction of a metal tray 0.5 m x 1 m, with a 90° bend in the middle, which was used to simulate

a floor/wall conjunction. The tray was at ambient temperatures prior to the start of each experiment.

In the cigarette ignition Experiments (l-4) the cigarette was placed within the crumpled or folded paper with several thicknesses of paper between the cigarette and the metal tray. In Experiments l-3, when the steady smouldering which was occurring looked unlikely to lead to flaming, the air movement around the paper towelling was increased by directing the edge of the air flow from a table fan (on 'low' setting) at the area that was smouldering. In the small flame ignition experiments the flame was applied to an upper edge of the paper.

For the experiment on the 2 panels of bar future (Experiment 8), 4 m of loosely crumpled paper towelling was used as the secondary ignition source, and a match was used as the primary ignition source. Loosely crumpled paper towelling was used as it had been observed that this burnt twice as fast as folded paper towelling. Before the 2 bar fixture panels were assessed, some specimens of the vinyl coated fabric and polyurethane foam were removed. Pieces of each were suspended from a laboratory stand and subjected to small flames on their lower ends (Experiments 9-11).

6. RESULTS

The results of the cigarette ignition experiments on the paper towelling are given in Table 2, the flame ignition experiments on the paper towelling in Table 3 and the flame ignition experiment on the bar fixture specimens in Table 4. Observation made during the experiments are listed in the Appendix.

7. DISCUSSION

The paper towelling ignited and smouldered four out of four times when a cigarette was placed in contact with it (Experiments 1-4, Table 2). The way the paper was prepared (either loosely crumpled or folded) made no difference to the likelihood of ignition occurring, but the smouldering rate following ignition did appear to be enhanced if there were multiple folds of paper adjacent to each other. However the transition from smouldering to flaming could not be achieved for any of the paper arrangements assessed without enhancing the air flow around the paper towelling. In the three experiments where the air flow was enhanced by a fan (l-3) flaming commenced within

1 to 46 ,seconds In Experiment 4, where the air flow around the paper towelling was not enhanced, the paper smouldered to completion without undergoing the transition to flaming. However strong glowing was visible during the smouldering of this specimen, and a similar specimen smouldering at a similar rate might undergo the transition to flaming under different conditions.

The paper towelling was readily ignited by small flames (Experiments 5-7, Table 3). The burning rate was twice as fast for loosely crumpled paper (Experiments 5-6) as it was for folded paper (Experiment 7).

The two bar fixture panels, when f'lxed at right angles to each other, were readily ignited by burning 4 m of loosely crumpled paper towelliig in the comer between them. The fust material to ignite was the vinyl coated fabric, which formed the outer cover for the bar fixture. However flame did not spread away from the ignition until the polyurethane foam also ignited. Flame then spread rapidly up the comer of the bar fixture before spreading laterally across the fixture (See Appendix, Experiment 8 observations). When the fire was extinguished, less than 6 minutes after ignition, the vinyl coated fabric and polyurethane foam were both completely consumed. The plywood panels were alight at this stage, but only a small amount of plywood had been consumed.

The vinyl coated fabric when examined by itself and contacted by small flames (Experiments 9, 11) ignited but did not continue to burn after removal of the flames. The polyurethane foam when examined by itself ignited easily from a small flame (Experiment 10) and burnt readily. Polyurethane foam comes in many grades and densities, with and without fire retardant additives. No information was provided on the grade of foam used. In the experiment on the two panels of bar fixtures (Experiment S), the polyurethane foam may have provided the fuel necessary for continuation of the burning.

8. CONCLUSIONS

1. Specimens of the paper towelling, both loosely crumpled and folded in layers, were ignited by a cigarette conforming to AS 3744 and underwent sustained smouldering.

2. Four metre lengths of the paper towelling, undergoing sustained smouldering, both loosely crumpled and folded in layers, when affected by a change in air flow patterns, underwent a transition from smouldering to flaming.

3. An ignition source comprising a flaming four metre length of the paper towelling loosely crumpled and placed in the comer formed by placing two vertical panels of the bar futture at right angles, ignited the bar fixture and as a result the vinyl coated fabric and polyurethane foam burnt till completely consumed.

9. REFERENCES

1. Standards Association of Australia. Furniture - Assessment of the ignitability of upholstered furniture.
Part 1: Ignition source - Smouldering Cigarette. AS 3744.1- 1989
Part 2: Ignition source - Match-flame equivalent, AS 3744.2 - 1989.

Table 1

List of Experiments

Experiment	Item assessed	Ignition Source
1	4 m paper towel, loosely crumpled	Cigarette, fan assisted
2	4 m paper towel, folded in 4 layers and loosely crumpled	Cigarette, fan assisted
3	4 m paper towel, folded in 32 layers	Cigarette, fan assisted
4	4 m paper towel, folded in 32 layers and slightly crumpled	Cigarette
5	4 m paper towel, loosely crumpled	Match - flame equivalent
6	4 m paper towel, loosely crumpled	Match
7	4 m paper towel, folded in 32 layers	Match
8	2 pieces of bar fixture, fixed at right angles	4 m of paper towel, loosely Crumpled
9	Vinyl coated fabric (100 mm x 20 mm approx) from bar fixture	Match
10	Flexible polyurethane foam padding (80 mm x 25 mm x 20 mm appmx) from bar fixtures	Match
11	Vinyl coated fabric (100 mm x 20 mm appmx) from bar fixtures	Match-flame equivalent

Table 2

Results of cigarette ignition experiments on 4 metre lengths of paper towelling

Experiment	Smouldering of paper achieved?	Time at which:			Comments
		Fan was directed at paper (Min:Sec)	Flaming commenced (Min:Sec)	Paper was substantially consumed (Min:Sec)	
1	Yes	9:24	9:25	10:30	
2	Yes	8:13	8:59	9:58	
3	Yes	17:00	17:02	19:20	
4	Yes	-	-	26:30	No flaming occurred

Table 3

Results of small flame ignition experiments on 4 metre lengths of paper towelling

Experiment	Ignition Source	Ignition Achieved?	Time of Flaming (Min:Sec)
5	Match-flame tquivalent	Yes	1:35
6	Match	Yes	2:12
7	Match	Yes	4:25

Table 4

Results of flame ignition experiments on bar fixture specimens

Experiment	Ignition Source	Specimen	Result
8	4 m paper towel	Bar fixture panels	Polyurethane and vinyl bunt till completely consumed, wood ignited
9	Match	Vinyl coated fabric	No flaming after ignition souxce are moved
10	Match	Polyurethane foam	Polyurethane burnt till completely consumed
11	Match-flame equivalent	Vinyl coated fabric	No flaming after ignition source removed

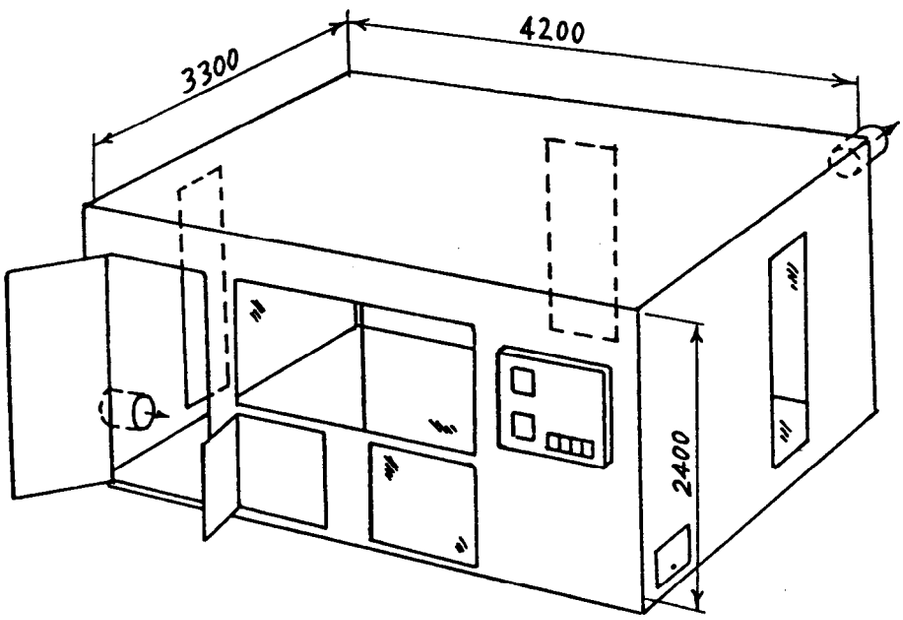

Figure 1. Furniture Fire Room

Appendix

Observations made during experiments

EXPERIMENT 1

Time (Min:Sec)	Event
0:00	Cigarette placed in crumpled paper towel
0:50	Paper compressed around cigarette
1:01	Smoke visible
1:49	Cigarette position adjusted
1:54	Paper held down around cigarette for 1 minute
3:34	Smoke increasing
4:34	Smoke decreasing
5:00	Steady smoke production
5:51	Paper held down around cigarette for 36 seconds
6:30	Smoke increasing
8:00	Smoke still increasing; paper towel smouldering strongly
9:24	Fan (on 'low' setting) directed at smouldering paper towel
9:29	Paper towel flaming
l0:30	Paper towel substantially consumed

EXPERIMENT 2

Time (Min:Sec)	Event
0:00	Cigarette placed inside crumpled paper towel
1:00	Cigarette position adjusted
1:16	Cigarette removed to check that it was still alight
1:46	Cigarette replaced inside crumpled paper towel
2:36	Cigarette repositioned
3:10	Smoke increasing
5:00	Paper smouldering strongly
8:13	Fan (on 'low' setting) directed at smouldering paper towel
8:59	Paper towel flaming
9:58	Flame out. Paper towel substantially consumed

EXPERIMENT 3

Time (Min:Sec)	Event
0:00	Cigarette placed in folds of paper towel
0:50	Smoke visible
1:40	Smoke increasing
8:00	Paper towel smouldering steadily
9:00	Smoke decreasing
9:41	Folds in paper towel opened for inspection
10:00	Smoke increasing
11:55	Fold in paper towel propped open; smoke increases
13:00	Paper towel smouldering strongly
17:00	Fan (on 'low' setting) directed at smouldering paper towel
17:02	Paper towel flaming
19:20	Paper substantially consumed

EXPERIMENT 4

Time (Min:Sec)	Event
0:00	Cigarette placed in folds of paper towel
0:52	Smoke visible
2:00	Paper towel smouldering slowly
7:03	Scorching visible about 8 folds above cigarette
9:03	Folds opened for inspection - paper scorched, very little smouldering
10:11	Fold with cigarette in propped open
12:00	Smouldering increasing slightly
13:00	Slow, steady smouldering
15:30	Cigarette mostly consumed, smouldering continues
17:30	Smoke increasing
20:00	Steady smouldering
22:00	Glowing visible
25:00	Smouldering decreasing, most paper towel consumed
26:30	Paper substantially consumed

EXPERIMENT 5

Time (Min:Sec)	Event
0:00	Match - flame equivalent applied to paper towel for 1 second. Paper towel ignites and flames
1:35	Flame out. Paper towel substantially consumed

EXPERIMENT 6

Time (Min:Sec)	Event
0:00	Match flame applied to paper towel for 2 seconds. Paper towel ignites and flames.
2:12	Flame out. Paper towel substantially consumed

EXPERIMENT 7

Time (Min:Sec)	Event
0:00	Match flame applied to top fold of paper towel for 1 second. Paper towel ignites and flames.
4:25	Flaming ceased. Paper towel substantially consumed.

EXPERIMENT 8

Time (Min:Sec)	Event
0:00	Ignition of 4 m of loosely crumpled paper towel by match flame.
1:04	Vinyl coated fabric alight and flaming
1:31	Steady flames to top of bar panels
2:00	Fire burning strongly in corner
2:20	Some lateral spread on bar panels
3:00	Approximately 50% of polyurethane foam and vinyl coated fabric involved
3:05	Room smoke logged
5:40	Fire has died down
5:50	Fire extinguished with carbon dioxide extinguisher

EXPERIMENT 9

Time (Min:Sec)	Event
0:00	Match flame applied to vinyl coated fabric. Ignition of fabric.
0:17	Match flame removed. All flames extinct.

EXPERIMENT 10

Time (Min:Sec)	Event
0:00	Match flame applied to polyurethane foam. Foam ignites and bums readily with flaming drops falling to floor
0:20	Polyurethane foam fully consumed. Flame ceases.

EXPERIMENT 11

Time (Min:Sec)	Event
0:00	Match - flame equivalent applied to vinyl coated fabric
0:10	Match - flame equivalent removed
0:13	Flaming on vinyl coated fabric ceases
0:16	Match - flame equivalent applied to vinyl coated fabric over 19 second period
0:39	Flames out No flame spread occurred.