1971 ——— NFPA ANNUAL MEETING PRESENTATION

AIR TRANSPORT CABIN MOCKUP FIRE EXPERIMENTS

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BACKGROUND

THIS IS THE THIRD TIME SINCE THE AVIATION SEMINAR HELD IN DALLAS IN 1964 THAT I HAVE BEEN HONORED BY BEING ASKED AGAIN TO SPEAK BEFORE THIS DISTINGUISHED GATHERING OF FIRE EXPERTS ON SOME OF THE MORE RECENT ACTIVITIES OF THE FAA, IN THE FIELD OF AIRCRAFT FIRE PROTECTION CONDUCTED AT ITS EXPERIMENTAL CENTER - NAFEC LOCATED AT ATLANTIC CITY. MY PARTICULAR INTEREST AND WORK IN THIS FIELD HAS BEEN WITH THE STUDY OF CABIN FIRES AND HOW THESE ARISE AND ARE RELATED TO THE COMBUSTIBLE CHARACTERISTICS OF INTERIOR MATERIALS USED IN AIRCRAFT CONSTRUCTION AND FURNISHING.

EVER SINCE 1947 WHEN THE FIRST REGULATION WAS ISSUED LIMITING BURN RATE TO 4 INCHES PER MINUTE, THE DEGREE OF FLAMMABILITY, SMOKE AND TOXIC GASES EMISSION OF THE MATERIALS HAS BEEN THE CAUSE OF INCREASED CONCERN OVER PASSENGER SAFETY, ESPECIALLY FOLLOWING A SURVIVABLE CRASH LANDING. HOWEVER, IT HAS ONLY BEEN SINCE AVIATION HAS BECOME A MASS TRANSPORTATION MEDIA THIS PAST DECADE WITH THE INTRODUCTION OF EVER LARGER CAPACITY AIRPLANES,

THAT MORE ATTENTION WAS DRAWN TO MINIMIZING THE DANGER OF FIRE BY RAISING THE FLAMMABILITY STANDARDS OF THE MATERIALS. THIS GROWING CONCERN OVER THE ROLE OF MATERIALS IN THE OVERALL FIRE SAFETY PROGRAM IN AVIATION PARALLELS THAT ELSEWHERE IN SURFACE TRANSPORTATION, BUILDING CONSTRUCTION, FURNISHINGS AND SPECIAL CLOTHING. THIS FOLLOWS FROM A GENERAL DESIRE BACKED IN PART BY LEGISLATION TO PROVIDE A SAFER AND MORE MEALTHFUL ENVIRONMENT FOR MANKIND.

RESPONSIBLE FOR MUCH OF THE DEVELOPMENT OF NEW MATERIALS AND REQUIREMENTS WAS THE B-727 SALT LAKE CITY CRASH IN NOVEMBER OF 1965, FOLLOWED WITHIN 2 MONTHS BY THE APOLLO DISASTER. THE SHOCK OF THESE EVENTS SERVED TO MOBILIZE ON A CRASH BASIS THE VAST TECHNICAL RESOURCES OF THE NATION, BOTH WITHIN THE GOVERNMENT-INCLUDING FAA AND NASA, OF WHICH DR. RADNOSKY HAS SPOKEN ABOUT, - AS WELL AS WITHIN PRIVATE INDUSTRY. THE RESULTS OF THESE COMBINED EFFORTS HAVE MADE IT POSSIBLE FOR FAA TO REVISE ITS FLAMMABILITY STANDARDS TO REQUIRE THAT ALL MATERIALS WITH MINOR EXEMPTIONS BE SELF-EXTINGUISHING WITHIN A BURN LENGTH OF EITHER 6 OR 8 INCHES DEPENDING UPON THEIR USE AND LOCATION IN THE AIRCRAFT. IN ADDITION TO THE MORE SEVERE FLAMMABILITY

REGULATIONS, FAA IS NOW PROPOSING A NEW RULE-MAKING THAT WOULD SET LIMITS FOR SMOKE EMISSION AT ACCEPTABLE VISIBILITY LEVELS. IT IS OF INTEREST TO NOTE THAT THE AVIATION INDUSTRY IN ANTICIPATION OF NEW FEDERAL REGULATIONS HAS LARGELY ADOPTED THE NEW PROPOSALS FOR THE MATERIALS USED IN THE WIDE-BODIED JET TRANSPORT AIRCRAFT. THIS IS REFLECTED IN THE EXTENSIVE USE IN THIS AIRPLANE OF NOMEX HONEYCOMB PANELING, FLAME-RETARDANT FOAM AND LOW-SMOKE THERMOPLASTICS SUCH AS POLYSULFONE, POLYCARBONATE, NYLON, AND FLUOROCARBONS.

INTRODUCTION

THE RESULTS OF THE TESTS TO BE PRESENTED IN SLIDES AND IN A FLIM ARE COVERED MORE COMPLETELY IN REPORT NO. FAA-RD-70-81, TITLED, "AIR TRANSPORT CABIN MOCKUP FIRE EXPERIMENTS" PUBLISHED IN DECEMBER 1970. FROM ITS INCEPTION THE OVERALL PROGRAM HAS MAINLY EMPHASIZED THE CONDUCT OF LABORATORY TESTS ON NEW MATERIALS TO JUSTIFY IMPROVED MATERIALS STANDARDS.[4]

IN CONTRAST, THE WORK DESCRIBED AT THIS TIME WILL BE CONCERNED WITH LARGE-SCALE TESTING ON SELECTED MATERIALS WHICH ARE MOST CRITICAL TO FIRE SAFETY, IN PARTICULAR SEAT UPHOLSTERY AND FOAM PADDING. IT IS WELL KNOWN THAT FIRE OFFICIALS, WITH GOOD REASON, ARE RELUCTANT TO ACCEPT AT FACE VALUE WITHOUT SUPPORTING EVIDENCE THE RESULTS OF LABORATORY SCALE TESTS IN TRYING TO PREDICT THE BEHAVIOR OF MATERIALS IN A TYPICAL LARGE FIRE. THUS, ONE OF THE MAIN OBJECTIVES OF THE PROJECT WAS TO COMPARE LABORATORY TEST DATA WITH THAT OBTAINED UNDER LARGE-SCALE FIRE CONDITIONS ON THE SAME MATERIALS. MATERIALS STUDIED WERE THOSE BELIEVED TO BE MOST HAZARDOUS IN VIEW OF THEIR RELATIVE ABUNDANCE IN CABINS AND GREATER COMBUSTIBILITY.[4] BECAUSE

OF THE LARGE COSTS AND EFFORTS NEEDED FOR CONDUCTING SERIES OF FULL-SCALE TESTS ON FUSELAGES, THIS APPROACH WAS NOT POSSIBLE OR PRACTICAL. INSTEAD, A RELATIVELY SMALL ENCLOSURE DESIGNED SPECIFICALLY TO RESIST FIRE WAS USED TO CONDUCT SOME 30 TESTS ON MATERIALS AND COMPONENTS. IN THESE TESTS ANYONE OF SEVERAL PARAMETERS COULD BE SELECTED FOR STUDY AND VARIED INDEPENDENTLY TO EVALUATE ITS PARTICULAR EFFECT ON THE EVOLUTION OF THE FIRE. EVEN SO, BECAUSE OF THE COMPLEX NATURE OF FIRE, AND LACK OF SCIENTIFIC DATA, IT HAS BEEN DIFFICULT TO GENERALIZE TOO FAR ON THE PHENOMENA. FIRE TECHNOLOGY AS A NEW SCIENCE IS LARGELY EMPIRICAL AND AS SUCH IS SURROUNDED BY MUCH CONTROVERSY OVER THE INTERPRETATION OF THE FIRE TESTS AND THE RELATIVE IMPORTANCE OF THE FACTORS WHICH CONTROL FIRE. IT IS HOPED THAT THIS PRESENTATION WILL PROMOTE A BETTER UNDERSTANDING OF HOW MATERIALS WITH DIFFERENT FLAMMABILITY RATINGS IGNITE AND BURN INSIDE A CABIN ENCLOSURE.

SLIDE #1

MAY WE NOW HAVE THE FIRST SLIDE.

THIS SHOWS A SCHEMATIC OF THE CABIN MOCKUP USED IN THE TESTS. THE STEEL ENCLOSURE IS INSULATED AND LINED WITH HIGH TEMPERATURE INERT MATERIALS WITH NO COMBUSTIBLES AND HAS A VOLUME OF 640 CUBIC FEET. IT IS EQUIPPED WITH FOUR WINDOWS WHICH WERE USED FOR OBSERVING AND PHOTOGRAPHING THE FIRE FROM OUTSIDE THE CABIN FROM DIFFERENT ANGLES, ONE OF THE WINDOWS OPPOSITE THE EXIT SIGN WAS USED TO MONITOR THE DECREASE IN VISIBILITY OF THE TARGET CAUSED BY THE SMOKE. VARIOUS SIZE OPENINGS TO THE OUTSIDE AIR WERE PROVIDED BY BLOCKING OFF THE 18-SQUARE FOOT AREA OF THE DOOR SPACE. IN ADDITION, A 1-FOOT SQUARE VENT HOLE WAS CUT IN THE ROOF TO PROVIDE VENTILATION TO THE FIRE IN SEPARATE TESTS. TEMPERATURE PROBES AT 24 DIFFERENT LOCATIONS ARE SHOWN BY RED CIRCLES. CONTINUOUS TEMPERATURE RECORDINGS WERE TAKEN OF THE SEAT AND THROUGHOUT THE CABIN AS SHOWN BY THE SCATTERING OF CIRCLES. HOWEVER EXCEPT FOR THE NEXT SLIDE ONLY THE TEMPERATURES RECORDED AT THE MID-CEILING POINT SHOWN CIRCLED IN BLACK WILL BE PRESENTED IN THE SLIDES THAT FOLLOW. THE LOCATIONS OF THE SAMPLING POINTS FOR SMOKE ARE SHOWN BY BLACK CIRCLES AND

FOR OXYGEN AND CARBON MONOXIDE BY BLUE CIRCLES. SMOKE DENSITY IN PERCENT WAS MEASURED BY THE ATTENUATION OF A BEAM OF LIGHT OVER A DISTANCE OF 1 FOOT USING A PHOTOCELL WITH RESPONSE SIMILAR TO THAT OF THE EYE. OXYGEN WAS MEASURED BY A PARAMAGNETIC TYPE OF DETECTOR AND CARBON MONOXIDE BY AN INFRARED TYPE OF DETECTOR. THE LOCATION OF THE HALON 1301 DISCHARGE PORT USED IN THE FIRE EXTINGUISHING TESTS IS SHOWN BY A GREEN CIRCLE. OTHER INSTRUMENTATION AND SAMPLING POINTS USED IN THE TESTS BUT NOT SHOWN HERE MEASURED CARBON DIOXIDE, COMBUSTIBLES, PRESSURES, HEAT FLUX, AND TOXIC GASES, OTHER THAN CARBON MONOXIDE. ALSO SHOWN INSIDE THE MOCKUP IS THE LOCATION OF THE FUEL LOAD AT ONE END AS WELL AS THE LOCATION OF THE IGNITION SOURCE UNDER THE FOAM PADS OR TRIPLE SEAT ASSEMBLY AS SHOWN BY THE CIRCLED CROSS. THIS WILL BE SHOWN MORE CLEARLY BY A COLOR FILM AT THE END OF THE SLIDE PRESENTATION.

SLIDE #2

MAY WE HAVE THE NEXT SLIDE.

A SERIES OF TEMPERATURE CURVES ARE SHOWN TAKEN OF A FIRE BURNING A TRIPLE SEAT CONSTRUCTED OF MATERIALS CURRENTLY IN USE IN AVIATION. THE SEAT WAS IGNITED FROM BELOW AS SHOWN IN THE FIRST SLIDE BY A SMALL PROPANE FLAME HELD IN CONTACT WITH THE CENTER BOTTOM CUSHION FOR A TIME PERIOD OF 1 MINUTE AND THEN SHUT OFF. BY THIS TIME THE NYLON UPHOLSTERY HAD CAUGHT FIRE AND STARTED TO BURN OF ITS OWN ACCORD. THE TEMPERATURE CURVES SHOW THE VERY SLOW RATE OF BURNING FOR THE FIRST 11 MINUTES AT THE END OF WHICH THE MAXIMUM CABIN TEMPERATURES ARE NOT MUCH OVER 200°F. OF PARTICULAR INTEREST IS THE EXTREMELY RAPID RISE IN TEMPERATURES AT 12 MINUTES. DURING THE INITIAL PHASE OF BURNING THE FOAM PAD IS APPARENTLY HEATED TO A TEMPERATURE AT WHICH IT RAPIDLY DECOMPOSES AND GENERATES LARGE QUANTITIES OF COMBUSTIBLE GASES WHICH ESCAPE BURNING AT THE SOURCE AND ACCUMULATE, BEING LIGHTER THAN AIR, UNDER THE CEILING. WHEN THE CONCENTRATION OF THESE GASES IN AIR REACH THEIR LOWER FLAMMABLE LIMIT, A FLASH FIRE SUDDENLY OCCURS WHICH RAPIDLY PROPAGATES OVER THE CEILING AREA. THE DISPLACEMENT OF THE CURVES WITH TIME GIVE SOME INDICATION OF THE TRANSIENT NATURE OF THE PHENOMENA.

THERMOCOUPLES LOCATED AT LOWER LEVELS SUCH AS NO. 18, 10 INCHES ABOVE FLOOR WHICH REGISTER ONLY MODERATE INCREASE IN TEMPERATURE, SHOW THAT THE FLASH FIRE IS RESTRICTED TO THE UPPER PART OF THE CABIN. THIS AGREES WITH THE SPEAKER'S OBSERVATION OF THE EXTENT OF DAMAGE TO AN AIRPLANE PASSENGER CABIN FROM AN ACTUAL FIRE.

SLIDE #3

MAY WE HAVE THE NEXT SLIDE.

A SERIES OF CURVES ARE SHOWN HERE OF THE FIRE PARAMETERS OF AN AIRCRAFT SEAT WITH CONVENTIONAL MATERIALS BURNING INSIDE THE CLOSED MOCKUP. CABIN CEILING TEMPERATURE, SMOKE DENSITY IN TERMS OF PERCENT LIGHT OBSCURATION, CARBON MONOXIDE AND OXYGEN CONTENT IN THE AIR ARE PLOTTED AGAINST TIME. THE CURVES SHOW THAT UP TO 8 MINUTES NO SIGNIFICANT BUILDUP OF SMOKE, TEMPERATURE OR CARBON MONOXIDE IS YET APPARENT. AFTER 8 MINUTES, SMOKE DEVELOPS VERY RAPIDLY AND WITHIN 2 MINUTES THE EXIT SIGN IS COMPLETELY OBLITERATED. DURING THIS TIME, THE RISE IN TEMPERATURE AND CARBON MONOXIDE ARE BOTH VERY GRADUAL AS IS THE CORRESPONDING DROP IN THE OXYGEN CONTENT OF THE AIR. AT 12 MINUTES, THE TEMPERATURE SUDDENLY JUMPS TO ABOUT 1000°F AND SMOKE BUILDS UP TO ALMOST 100 PERCENT, CARBON MONOXIDE GOES OFF SCALE AT 1.5 PERCENT, AND THE OXYGEN IS RAPIDLY DEPLETED AND DROPS TO ABOUT 3 PERCENT. AT THIS POINT OPEN FLAMING CEASES BECAUSE OF LACK OF OXYGEN AFTER THE FLASH FIRE HAS TERMINATED. THIS RAPID SEQUENCE OF EVENTS LASTS ONLY ABOUT 2 MINUTES. FIRE DAMAGE IN THIS TEST WAS LIMITED BY THE AMOUNT OF AVAILABLE OXYGEN. ONLY ABOUT 2 POUNDS OF COMBUSTIBLE

MATERIALS WERE CONSUMED IN THE CLOSED MOCKUP.

SLIDE #4

MAY WE HAVE THE NEXT SLIDE.

THE ONLY DIFFERENCE HERE IN THE TEST CONDITIONS WITH THE PREVIOUS SLIDE IS THAT THE SEAT WAS CONSTRUCTED OF SELF-EXTINGUISHING MATERIALS CONSISTING OF FLAME-RETARDANT URETHANE FOAM FOR THE CUSHIONS AND NOMEX FOR THE UPHOLSTERY FABRIC. ALSO SINCE VERY LITTLE BURNING WAS OBTAINED USING A PROPANE FLAME AS IN THE PREVIOUS SLIDES, INSTEAD A KEROSENE FIRE WAS BUILT UNDER THE SEAT TO IGNITE THE MATERIALS. WITH THE MUCH LARGER IGNITION SOURCE, SMOKE DEVELOPS VERY RAPIDLY AND THERE IS COMPLETE OBSCURATION OF THE EXIT SIGN WITHIN LESS THAN 2 MINUTES. MAXIMUM CARBON MONOXIDE ONLY REACHES 0.4 PERCENT, WHILE MAXIMUM CEILING TEMPERATURE ONLY REACHES 400°F. THERE IS NO FLASH FIRE AS EVIDENCED BY THE GRADUAL DECLINE OF THE OXYGEN CURVE. ALTHOUGH THE KEROSENE FLAMES WERE LARGE, ONLY THE MIDDLE SEAT SUFFERED SOME FIRE DAMAGE. THE TWO ADJOINING SEATS OF THE ASSEMBLY SUSTAINED ALMOST NO DAMAGE AS WILL BE SHOWN LATER IN THE MOVIE.

SLIDE #5

MAY WE HAVE THE NEXT SLIDE.

A SERIES OF CURVES ARE SHOWN HERE OF A URETHANE FOAM PAD FIRE IGNITED FROM BELOW BY A SMALL PROPANE TORCH. AFTER 60 SECONDS WHEN SELF-FLAMING OF THE FOAM HAD OCCURRED THE IGNITION SOURCE WAS EXTINGUISHED. RAPID GENERATION OF SMOKE OCCURRED AFTER 1 MINUTE. ANOTHER MINUTE WAS REQUIRED BEFORE THE CABIN CEILING TEMPERATURE AND CARBON MONOXIDE BEGAN TO REGISTER AN INCREASE. AT ABOUT 2.5 MINUTES, WHEN SMOKE HAD REACHED THE 90% OBSCURATION LEVEL BOTH TEMPERATURE AND CARBON MONOXIDE EXPERIENCED A VERY RAPID RISE, WITH TEMPERATURE GOING UP TO 1500°F AND CARBON MONOXIDE GOING OFF SCALE AT 1.5%. A CORRESPONDING RAPID DEPLETION OF OXYGEN IN THE AIR TO ABOUT 3 PERCENT OCCURS DURING THE SAME PERIOD WHICH IS TYPICAL OF THE FLASH FIRE.

SLIDE #6

MAY WE HAVE THE NEXT SLIDE.

A SERIES OF CURVES ARE SHOWN HERE OF A FR URETHANE FOAM FIRE IN THE CLOSED MOCKUP. THE FOAM IS VERY SIMILAR IN APPEARANCE AND FEEL TO THE FOAM IN THE PREVIOUS SLIDE EXCEPT THAT IT HAS BEEN TREATED WITH CHEMICAL ADDITIVES TO MAKE IT SELF-EXTINGUISHING. THIS FOAM IS BEING USED IN THE NEW WIDE-BODIED JET TRANSPORTS, ALTHOUGH AS YET THERE IS NO OFFICIAL FAA REQUIREMENT FOR ITS USE. IN THE TEST THE PROPANE FLAME - 10 INCHES IN HEIGHT AND HELD IN CONTACT FOR 12 MINUTES WITH THE UNDERSIDE OF THE PAD ONLY SUCCEEDED IN BURNING A 3 TO 6-INCH CIRCULAR HOLE THROUGH THE 8-INCH THICK PAD. THERE WAS NO TENDENCY FOR THE FOAM TO BURN OUTSIDE THE AREA OF DIRECT BURNER FLAME IMPINGEMENT. THE CURVES SHOW NO INCREASE IN TEMPERATURE, AND A VERY SLIGHT EFFECT ON OXYGEN CONTENT OR CARBON MONOXIDE. THE ONLY SIGNIFICANT PARAMETER TO REGISTER ANY INCREASE IS SMOKE. THIS REACHES A 30 PERCENT LEVEL WHICH WAS NOT HIGH ENOUGH TO OBSCURE THE EXIT SIGN.

SLIDE #7

MAY WE HAVE THE NEXT SLIDE.

THE TEST CONDITIONS HERE ARE THE SAME AS IN THE PREVIOUS SLIDE EXCEPT THAT A MUCH LARGER IGNITION SOURCE - A KEROSENE FIRE - WAS USED FOR BURNING THE FOAM. SMOKE IS SHOWN TO DEVELOP VERY RAPIDLY AND COMPLETELY OBSCURS THE CABIN WITHIN A HALF MINUTE.

TEMPERATURE REACHES A MAXIMUM OF 300°F. OXYGEN DROPS TO ONLY 18 PERCENT. CARBON MONOXIDE INCREASES TO 0.3 PERCENT. DROP IN TEMPERATURE AND INCREASE IN OXYGEN FROM CABIN LEAKAGE SHOW THAT THE COMBUSTION OF THE FOAM CEASED AFTER THE KEROSENE WAS CONSUMED IN ABOUT 3 MINUTES. THERE WAS NO FLASH FIRE IN THIS TEST.

WERE RECORDED AND THE FOAM WAS TOTALLY CONSUMED WITHIN A FEW MINUTES.

SLIDE #9

MAY WE HAVE THE NEXT SLIDE.

THE TEST CONDITIONS HERE ARE THE SAME AS IN THE PREVIOUS SLIDE EXCEPT THAT FR FOAM INSTEAD OF UNTREATED FOAM WAS BURNED IN THE VENTED CABIN. THE CURVES ARE SIMILAR TO THOSE OBTAINED IN THE FIRE TESTS ON THE REGULAR FOAM. THE VERY RAPID RISE IN TEMPERATURE FROM 250°F TO 1700°F WITHIN 1 MINUTE ACCOMPANIED BY A RAPID DROP IN OXYGEN DOWN TO 3 PERCENT IS TYPICAL OF THE FLASH FIRE. COMPLETE DESTRUCTION OF THE FR FOAM AND VERY HIGH TEMPERATURES WERE OBTAINED FOR THE VENTILATED CABIN. THE RESULTS WERE UNEXPECTED ON THE BASIS OF OUTDOORS FIRE TESTS ON THE SAME FOAM MATERIALS. IN THE OUTDOOR TESTS, THE FR FOAM WAS SELF-EXTINGUISHING TO A KEROSENE FIRE AND WAS ONLY PARTIALLY CONSUMED IN THE AREA OF DIRECT FLAME IMPINGEMENT.

SLIDE #10

MAY WE HAVE THE NEXT SLIDE.

SHOWN HERE ARE THE CONCLUSIONS DERIVED FROM THE FIRE TESTS IN WHICH AIRCRAFT SEATS AND URETHANE FOAM PADS WERE BURNED UNDER VARIOUS CONTROLLED CONDITIONS.

1. FLASHOVER (i. e. FLASH FIRE) HAZARDS WITHIN AN AIRPLANE CABIN FROM SEAT FIRES CAN LARGELY BE ELIMINED BY THE USE OF SELF-EXTINGUISHING MATERIALS.

2. BURNING OF FLAME-RETARDANT (FR) FOAM CAN RESULT IN A FLASH FIRE, BUT ONLY UNDER CONDITIONS OF SEVERE HEATING WITH INDUCED AIR DRAFTS IN A VENTED CABIN.

3. EXTENSIVE DAMAGE AND TEMPERATURES OVER 2000°F CAN RESULT FROM A VENTILATED CABIN FIRE.

4. DENSE SMOKE DEVELOPS VERY RAPIDLY DURING THE EARLY STAGES OF A CABIN FIRE INVOLVING SEAT MATERIALS, WELL BEFORE ANY SIGNIFICANT INCREASES IN AIR TEMPERATURE AND CARBON MONOXIDE ARE EXPERIENCED THAT COULD BE CONSIDERED HARMFUL.

5. ALTHOUGH LABORATORY TESTS PROVIDE USEFUL DATA ON THE FIRE HAZARDS OF MATERIALS, THESE TESTS SHOULD BE SUPPLEMENTED BY TESTS ON COMPLETE ASSEMBLIES INSIDE A CABIN MOCKUP.

13. FIRE AFTER 15 MINUTES
NOTE* RED GLOW CAUSED BY FLASH FIRE
14. FIRE DAMAGE IN ROOF-VENTED CABIN (1-FOOT-SQUARE OPENING) -SEVERE

15. IMPROVED SEAT - NOMEX UPHOLSTERY AND FLAME-RETARDANT URETHANE PADDING
IGNITION - PROPANE/AIR BURNER, 10-MINUTE BURN TIME, FLAMES 10 INCHES HIGH
(ACTION 6X NORMAL SPEED)

16. FIRE AFTER 2 MINUTES

17. FIRE AFTER 6 MINUTES

18. FIRE AFTER 8 MINUTES

19. IGNITION OF SEAT - SIDE VIEW

20. FIRE AFTER 6 MINUTES

21. FIRE DAMAGE - ONLY TO BOTTOM CUSHION

22. IMPROVED SEAT - SAME AS IN PREVIOUS TEST
IGNITION - KEROSENE FIRE - (8 OUNCES IN 1-FOOT-SQUARE PAN) - 3-MINUTE (APPROX.) BURN TIME

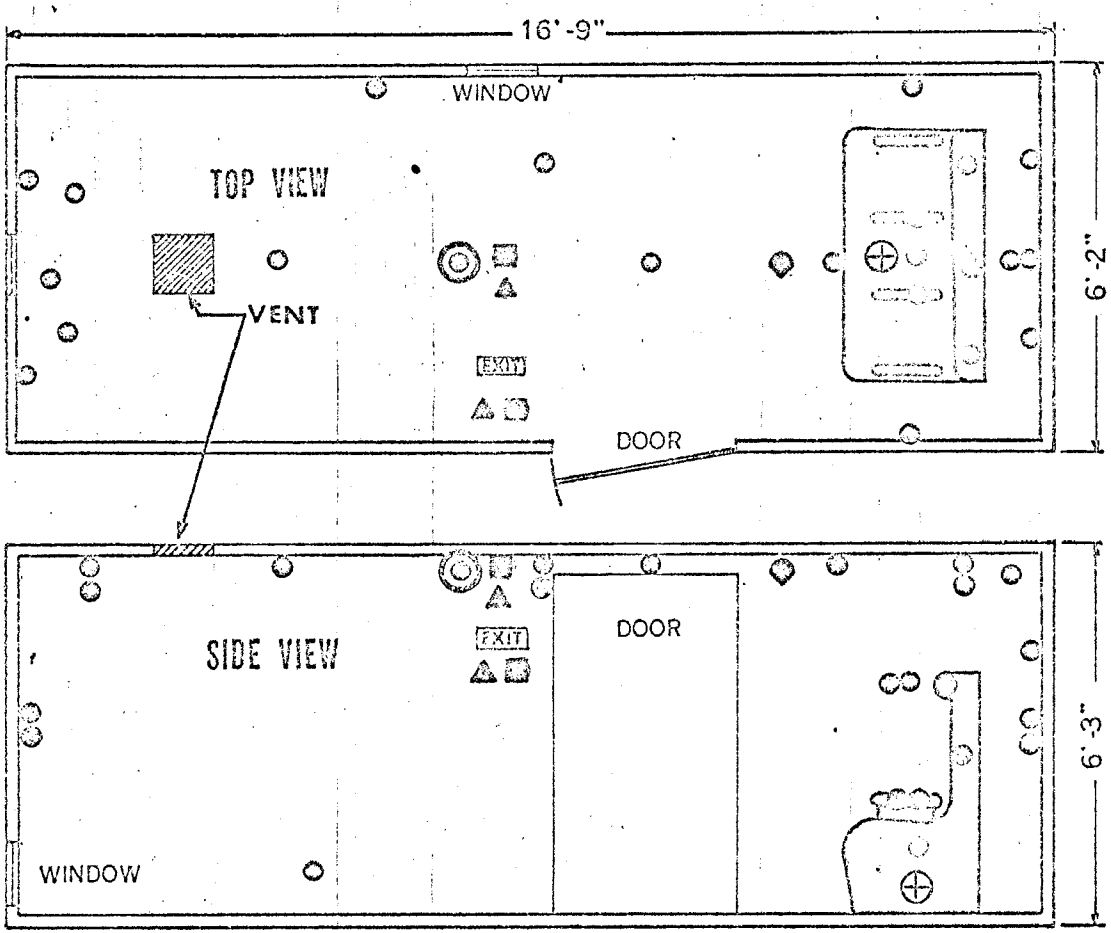
23. IGNITION OF SEAT - SIDE VIEW

24. FIRE DAMAGE - ONLY TO CENTER SEAT
MAX. TEMP. RISE AT CEILING 400°F
NO FLASH FIRE

THIS CONCLUDES THE PRESENTATION.

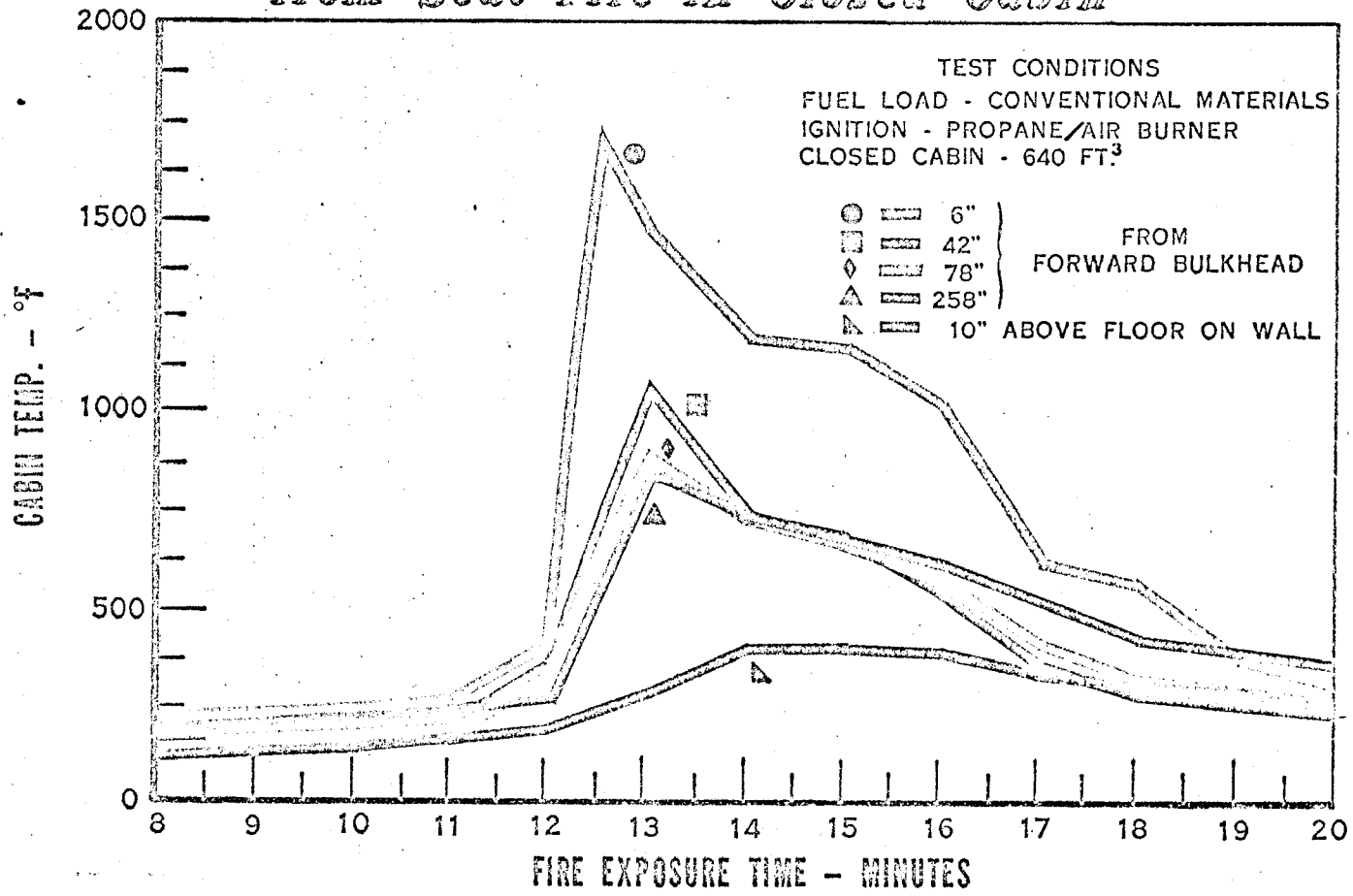
ARE THERE ANY QUESTIONS?

Cabin Mockup and Instrumentation



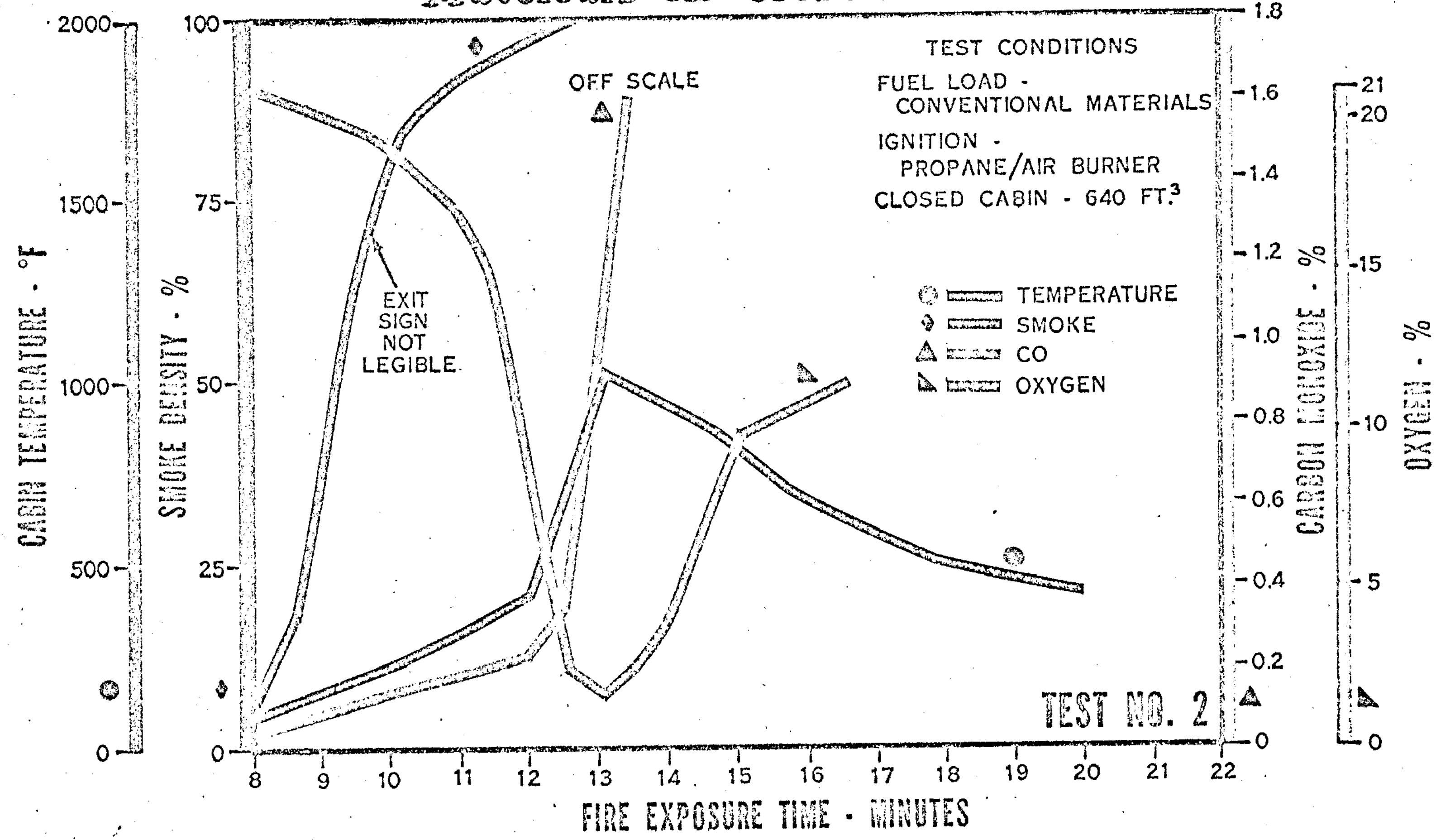
SLIDE #1

Ceiling Flashover Temperatures from Seat Fire in Closed Cabin



SLIDE 2

Seat Fire Parameters with Conventional Materials in Closed Cabin



SLIDE #3