COMBUSTION AND FIRES IN LOW GRAVITY

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FIRE SAFETY IN NASA HUMAN-CREW SPACECRAFT

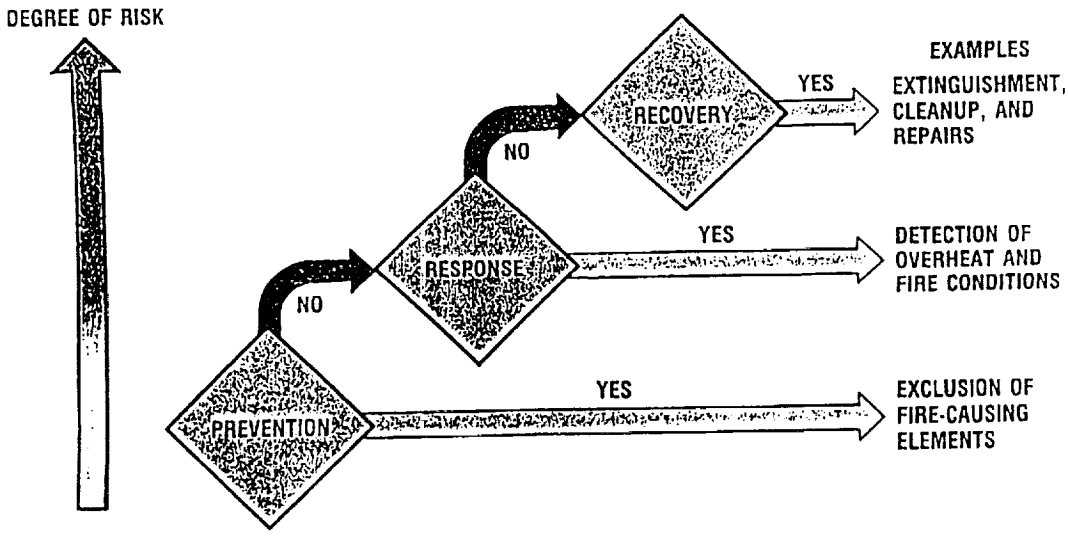
- FIRE SAFETY ALWAYS RECEIVES PRIORITY ATTENTION IN NASA MISSION DESIGNS AND OPERATIONS, WITH EMPHASIS ON FIRE PREVENTION AND MATERIAL ACCEPTANCE STANDARDS

- RECENTLY, INTEREST IN SPACECRAFT FIRE-SAFETY RESEARCH AND DEVELOPMENT HAS INCREASED BECAUSE

  - IMPROVED UNDERSTANDING OF THE SIGNIFICANT DIFFERENCES BETWEEN LOW-GRAVITY AND NORMAL-GRAVITY COMBUSTION SUGGESTS THAT PRESENT FIRE-SAFETY TECHNIQUES MAY BE INADEQUATE OR, AT BEST, NON-OPTIMAL

  - THE COMPLEX AND PERMANENT ORBITAL OPERATIONS IN *FREEDOM* DEMAND A HIGHER LEVEL OF SAFETY STANDARDS AND PRACTICES

SPACECRAFT FIRE RISK STRATEGIES



SPACECRAFT FIRE-SAFETY STATE OF THE ART

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PREVENTION

- LARGE DATABASE AVAILABLE ON ACCEPTABLE "NON-FLAMMABLE" MATERIALS
- NASA TEST METHODS UNDER EVALUATION BY NIST; MODIFICATIONS ARE SUGGESTED
- RECENT RESEARCH DEFINED LOW-GRAVITY FLAMMABILITY LIMITS AND VENTILATION EFFECTS

FIRE DETECTION

- AIRPLANE SMOKE DETECTOR DESIGNS ADAPTED TO SPACECRAFT
- NO SPACE-RELATED DATA

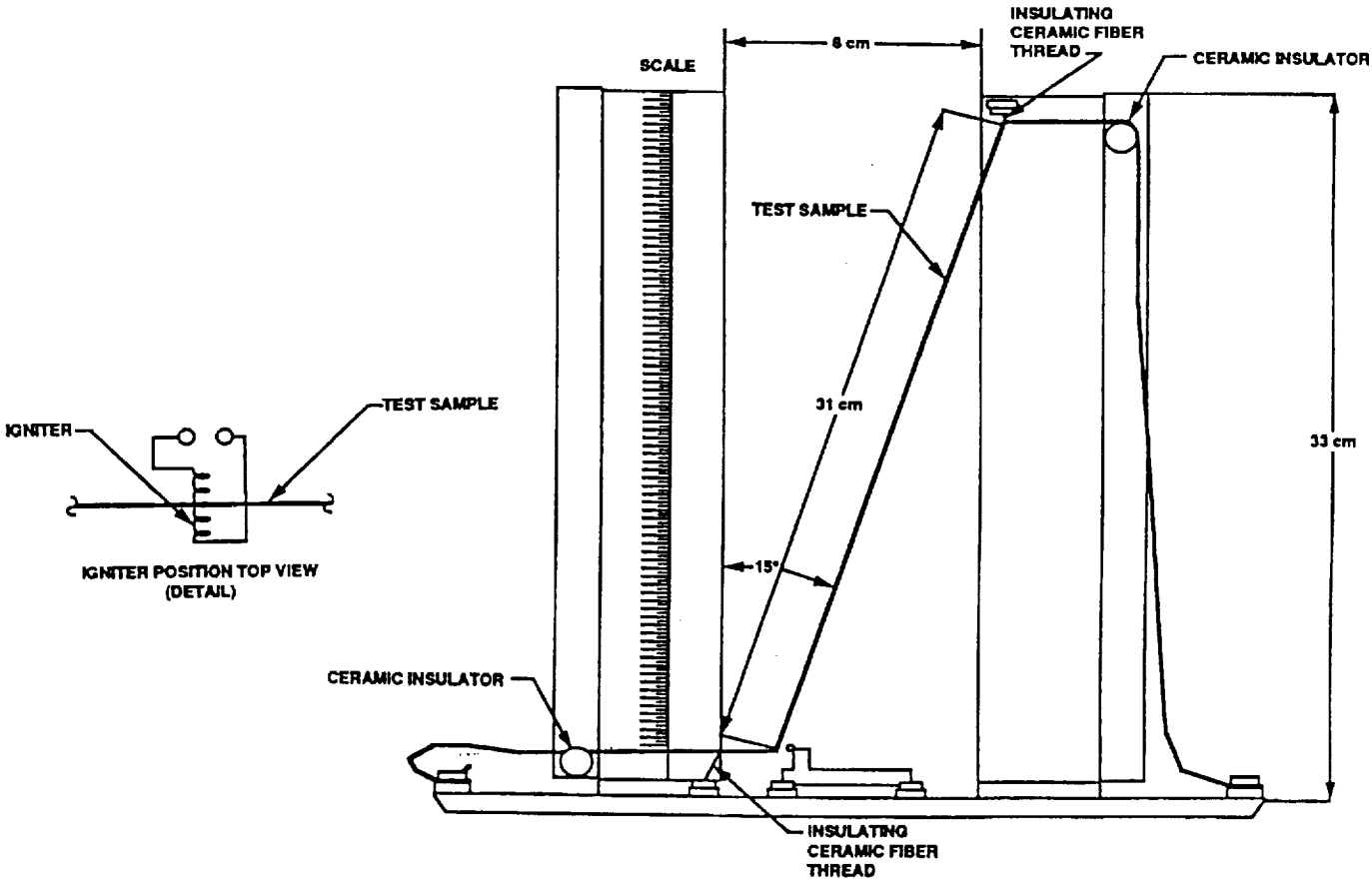
FIRE EXTINGUISHMENT

- SPACECRAFT EXTINGUISHING AGENTS SELECTED BY SYSTEM ANALYSES
- RECENT RESEARCH DEFINED RELATIVE EFFICIENCY OF AGENTS AS ATMOSPHERIC SUPPRESSANTS

CURRENT PRACTICES IN FIRE PREVENTION FOR SPACECRAFT

- LIMITING MATERIALS, AS FAR AS PRACTICAL, TO THOSE THAT ARE "NON-FLAMMABLE", BASED ON NHB 8060.1 FLAMMABILITY TESTS
- AVOIDANCE OF IGNITION SOURCES, THROUGH ELECTRICAL INSULATION AND GROUNDING, OVERPRESSURE CONTAINMENT, AND THERMAL/-ELECTRICAL OVERLOAD PROTECTION
- GOOD HOUSEKEEPING PRACTICES FOR WASTE STORAGE AND DISPOSAL, FLUID LEAK PREVENTION, "FLAMMABLES" ISOLATION, AND SO ON

NASA ELECTRICAL WIRE INSULATION FLAMMABILITY TEST
NHB 8060.1C TEST 4



PROBLEMS IN FIRE PREVENTION FOR SPACECRAFT

- MANY COMMON ITEMS, PARTICULARLY COMMERCIAL INSTRUMENTS AND PERSONAL USE ITEMS, CANNOT PASS THE FLAMMABILITY TEST. THESE ARE PERMITTED ONBOARD SPACECRAFT WHEN CONTROLLED THROUGH ISOLATION, STORAGE PROTECTION, OR BARRIERS. NEVERTHELESS
  - CONFIGURATION CHANGES MAY OCCUR DURING MISSIONS
  - FOAM MATERIALS, VELCRO PATCHES, ETC., POSE SPECIAL FLAMMABILITY PROBLEMS (SMOLDERING, PARTICLE EXPULSION)

- MATERIAL FIRE HAZARDS MAY INCREASE IN THE FUTURE FOR *FREEDOM*
  - GREATER VARIETY OF COMMERCIAL AND TEST MATERIALS
  - HIGHER PROBABILITY OF EXPOSURE TO IGNITION "INCIDENTS"
  - CHANGES AND RELAXATION OF SAFETY ATTITUDES (LONG MISSIONS)

- CURRENT UNDERSTANDING OF MICROGRAVITY COMBUSTION QUESTIONS THE RELEVANCE OF NORMAL-GRAVITY-TEST ACCEPTANCE STANDARDS TO LOW-GRAVITY FLAMMABILITY BEHAVIOR

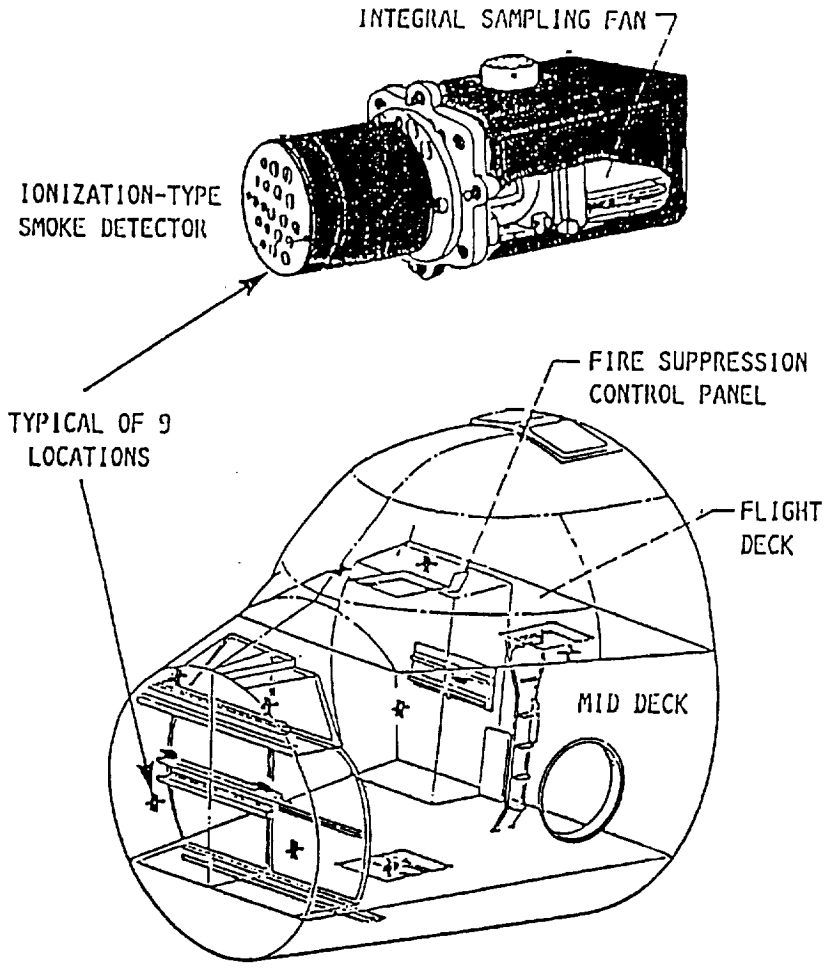
CURRENT PRACTICES IN FIRE DETECTION FOR SPACECRAFT

- SHUTTLE IS EQUIPPED WITH NINE STATE-OF-THE-ART IONIZATION SMOKE DETECTORS (CARGO-BAY LABORATORIES HAVE SIX OR MORE ADDITIONAL DETECTORS)

- SHUTTLE DETECTORS HAVE INTERNAL FANS FOR PARTICLE SEPARATION (DUST PARTICLE BYPASS OF IONIZATION CHAMBER) AND FOR ADEQUATE ATMOSPHERIC SAMPLING

- SHUTTLE DETECTORS ARE MONITORED TO MEASURE PARTICLE CONCENTRATION AND TO ALARM AT PRESET CONCENTRATIONS

FIRE DETECTION IN THE SHUTTLE



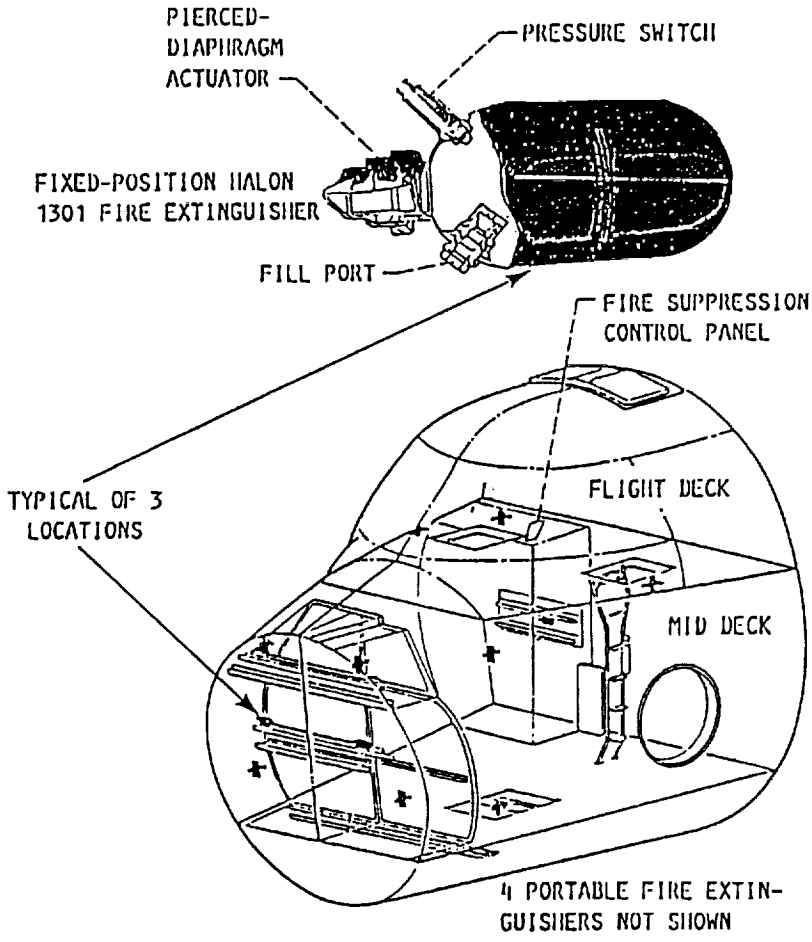
PROBLEMS IN FIRE DETECTION FOR SPACECRAFT

- THE EFFECTIVENESS OF STANDARD SENSORS IN RESPONDING TO THE UNIQUE CHARACTERISTICS OF MICROGRAVITY FIRES IS UNCERTAIN
  - SMOKE AND AEROSOL PARTICLE SIZE, SIZE DISTRIBUTION, AND DENSITY ARE UNKNOWN
  - MICROGRAVITY FLAMES ARE STEADY (FLICKER CIRCUITS DO NOT IDENTIFY THESE FLAMES)
  - THE HEAT AND MASS TRANSPORT OF FIRE "SIGNATURES" TO THE SENSOR ARE DIFFERENT, INFLUENCING RESPONSE TIMES
- SPECIFIC FIRE SCENARIOS AND RISK MODELS, NECESSARY TO GUIDE OPTIMUM SENSOR SPACING AND LOCATION, ARE LACKING
- TRADEOFFS FOR OPTIMUM DECISIONS ON SENSITIVITY VS. FALSE ALARMS, MANUAL VS. AUTOMATED RESPONSES, AND SO FORTH, ARE LACKING

CURRENT PRACTICES IN FIRE EXTINGUISHMENT FOR SPACECRAFT

- SHUTTLE EQUIPPED WITH THREE FIXED AND FOUR PORTABLE STATE-OF-THE-ART HALON 1301 FIRE EXTINGUISHERS
- OPERATION OF FIXED EXTINGUISHER FROM PANEL REQUIRES ACTUATION OF AN "ARM" SWITCH FOLLOWED BY THE "DISCHARGE" SWITCH
- NORMAL COMBUSTION PRODUCTS OF CO_2 AND WATER ARE REMOVED FROM THE ATMOSPHERE BY THE PRESENT ENVIRONMENTAL CONTROL SYSTEM
- OTHER COMBUSTION PRODUCTS, SUCH AS CO, ARE REMOVABLE, IN TRACE QUANTITIES ONLY, BY AN ACTIVATED CARBON FILTER
- MISSION WOULD BE TERMINATED AFTER EXTINGUISHER DISCHARGE FOR SUBSEQUENT GROUND CLEANUP

FIRE EXTINGUISHMENT IN THE SHUTTLE



SPACE STATION *FREEDOM* FIRE PROTECTION

MAJOR ISSUES

- THE COMPLEX CONFIGURATION, VARIED CREW ACTIVITIES, AND SCIENTIFIC AND COMMERCIAL OPERATIONS MAY PROVIDE ADDITIONAL FIRE HAZARDS. THE LONG-TERM, PERMANENT ORBITAL MISSION INCREASES THE PROBABILITY OF FIRE "EVENTS" TO NEAR UNITY.

- THE INITIAL ASSEMBLY PERIOD POSES PARTICULAR CONCERNS
  - NO MEANS OF REMOTE MODULE ISOLATION OR FIRE CONTROL TO COMBAT FIRE EVENTS DURING INTERIM UNATTENDED TIMES
  - INCREASED MATERIAL FLAMMABILITY IN HIGHER-O_2-CONCENTRATION ATMOSPHERES (REQUIRED FOR EXTRAVEHICULAR ACTIVITIES)

- THE DEPENDENCIES AND TRADE-OFFS BETWEEN MANUAL AND AUTOMATED FIRE PROTECTION ARE UNRESOLVED. THE AUTOMATED DATA MANAGEMENT SYSTEM MAY FAIL DURING A FIRE, FOR EXAMPLE.

- THE APPLICATION OF THE LIMITED KNOWLEDGE OF LOW-GRAVITY FIRE BEHAVIOR TOWARD PRACTICAL FIRE-PROTECTION HARDWARE AND OPERATIONS FOR SPACE IS STILL IN A VERY EARLY STATE OF DEVELOPMENT

- SEVERE DESIGN CONSTRAINTS ON POWER, MASS, AND VOLUME DEMAND SIMPLE YET HIGHLY EFFICIENT DETECTION-SUPPRESSION SYSTEMS

SUMMARY

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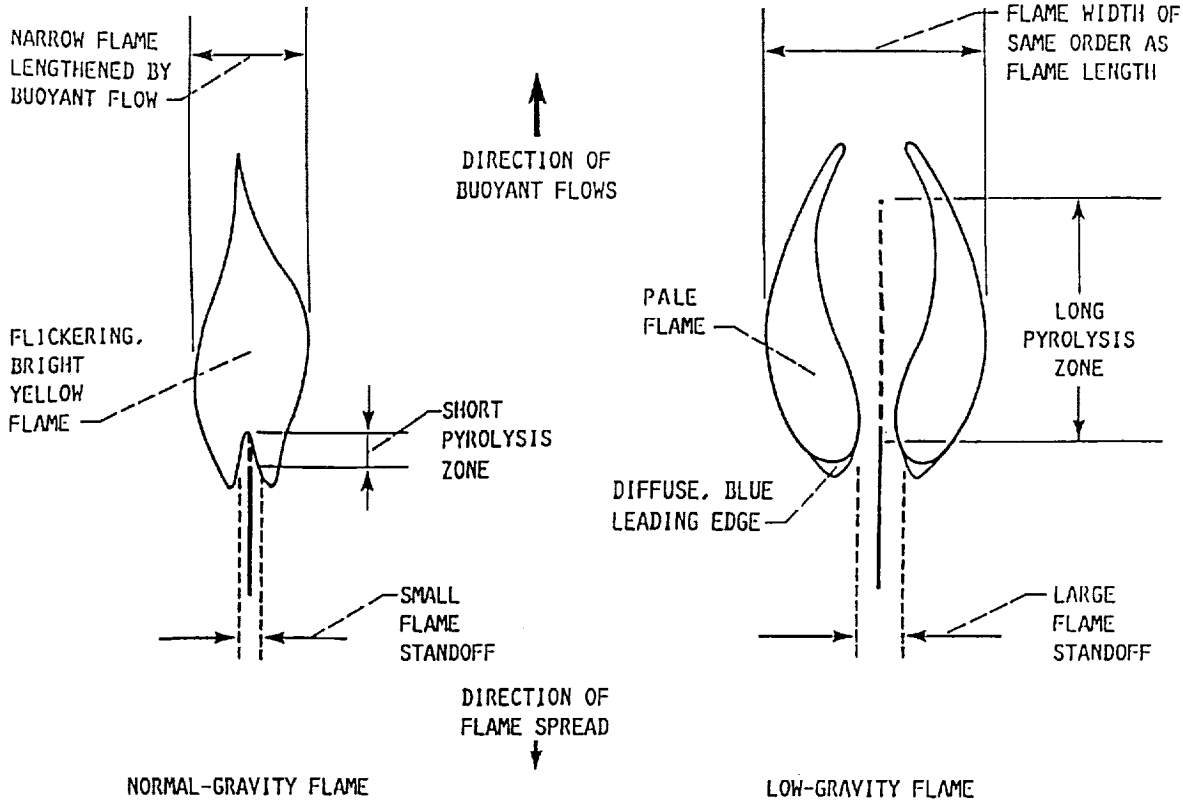
- PRESENT STATUS CURRENT SPACECRAFT FIRE-SAFETY PRACTICES, BASED MAINLY ON SKILLED APPLICATIONS OF GROUND AND AIRCRAFT TECHNIQUES, ARE CONSIDERED ADEQUATE

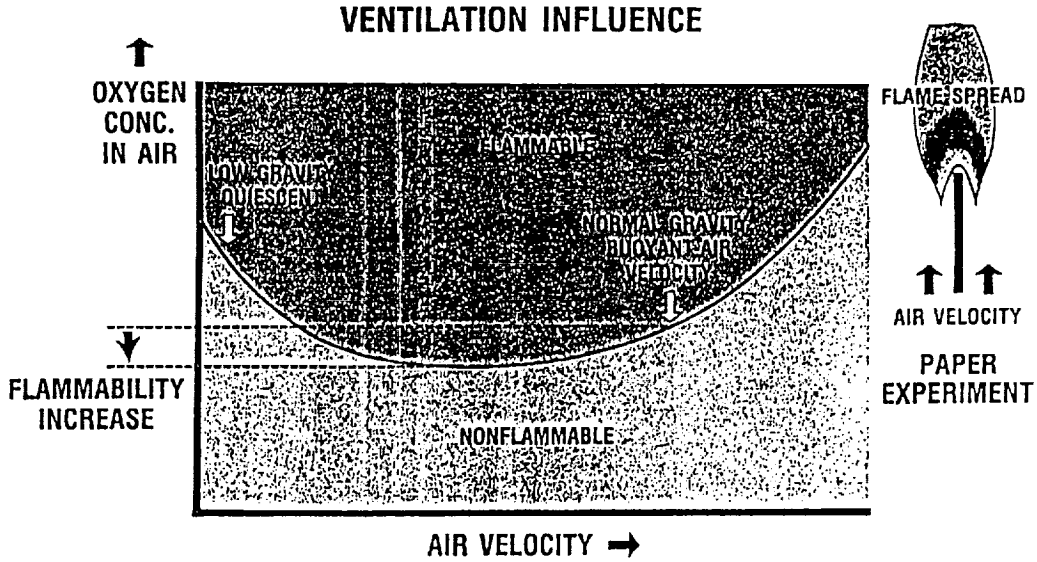
- ISSUES FOR FUTURE SPACECRAFT AND MISSIONS, HOWEVER, ADVANCES IN FIRE-SAFETY STANDARDS AND TECHNOLOGY ARE ESSENTIAL
  - THE GROWING BODY OF KNOWLEDGE OF MICROGRAVITY COMBUSTION SCIENCE OFFERS THE OPPORTUNITY FOR IMPROVED AND MORE EFFICIENT FIRE-SAFETY TECHNIQUES
  - THE COMPLEX, PERMANENT ORBITAL OPERATIONS OF *FREEDOM* IMPOSE NEW DEMANDS ON FIRE SAFETY AND INCREASE THE PROBABILITY OF FIRE INCIDENTS
  - NEW INFORMATION IS NEEDED ON THE APPLICATION OF MICROGRAVITY COMBUSTION SCIENCE AND QUANTITATIVE RISK ASSESSMENTS TO PRACTICAL CONCEPTS OF FIRE SAFETY

- BENEFITS RESEARCH AND TECHNOLOGY IN SPACECRAFT FIRE SAFETY PROMISE REDUCED RISK FACTORS AND IMPROVED FLEXIBILITY AND EFFICIENCY IN SPACECRAFT TECHNIQUES TO PROMOTE GREATER MISSION SAFETY AND ENCOURAGE BETTER UTILIZATION OF FUTURE SPACECRAFT

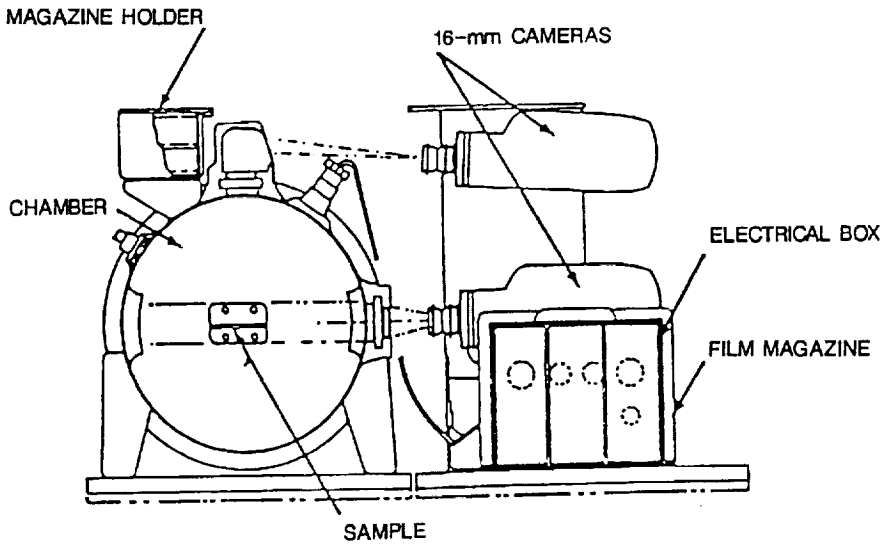
COMPARISON OF FLAMES ON THIN SOLID SURFACES (PAPER, FOR EXAMPLE)



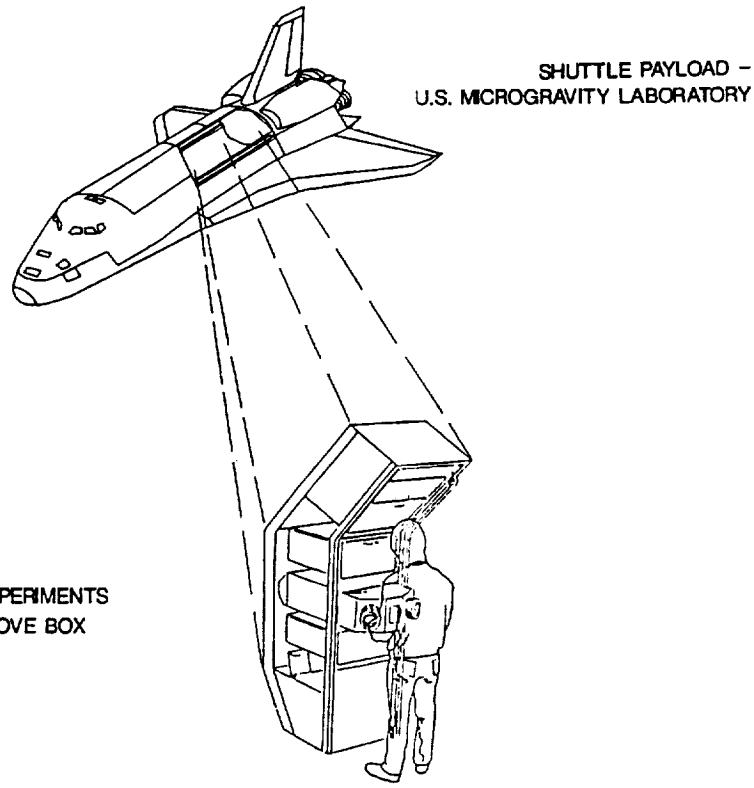
POTENTIAL ENHANCEMENT OF FLAMMABILITY BY LOW AIR FLOWS AT LOW GRAVITY



SOLID SURFACE COMBUSTION EXPERIMENT APPARATUS



GLOVEBOX EXPERIMENTS ON THE SHUTTLE



COMMON FACILITY
FOR 3 COMBUSTION EXPERIMENTS
IN RACK-MOUNTED GLOVE BOX

PROBLEMS IN FIRE EXTINGUISHMENT FOR SPACECRAFT

- LIMITED SELECTION OF USEFUL EXTINGUISHING AGENTS FOR SPACE
  - NONGASEOUS OR MIXED-PHASE (FOAM) TYPES NOT SUITABLE
  - REMOVAL OF AGENT AND PRODUCTS FROM CLOSED ENVIRONMENT IS A CRITICAL CONCERN
- HALON 1301 AND SIMILAR HALOCARBONS ARE TO BE PHASED OUT OF USE IN NEXT DECADE BY INTERNATIONAL AGREEMENTS
- EFFECTIVENESS OF AGENT DISPERSAL AND DELIVERY MODE UNDER THE DIFFERING MASS AND HEAT TRANSPORT RATES IN MICROGRAVITY HAVE YET TO BE DEMONSTRATED
- FOR THE PERMANENT ORBITAL MISSIONS OF *FREEDOM*, UNKNOWN LONG-TERM TOXIC AND CORROSIVE EFFECTS OF AGENT AND PRODUCT RESIDUES ARE A CONCERN

EXPERIMENTAL STUDIES AND DEMONSTRATIONS OF MICROGRAVITY FIRE BEHAVIOR RELEVANT TO FIRE SAFETY

IN SPACE	SKYLAB	1974
	SHUTTLE SSCE (STS 41, 40)	1990, 1991
PARABOLIC AIRPLANE FLIGHTS	KIMZEY	1966
	NASA LEWIS, ESA	CURRENT
FREE-FALL DROP TOWERS	NASA LEWIS 5.2 SEC:	
	WIRE INSULATION	1971
	SOLID SAMPLES	1974 TO CURRENT
	NASA LEWIS 2.2 SEC:	
	SOLID SAMPLES	1970 TO CURRENT
	PARTICLE CLOUDS	1979 TO 1990
	PREMIXED GASES	1980 TO CURRENT
	VARIOUS UNIVERSITY (1.0 TO 1.4 SEC):	
	DROPLETS, AEROSOLS	CURRENT

SESSION III:

WIRING REQUIREMENTS

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NASA WIRING FOR SPACE APPLICATIONS PROGRAM

JULY 23-24, 1991

DR. DANIEL R. MULVILLE
DIRECTOR, TECHNICAL STANDARDS DIVISION
NASA HEADQUARTERS

- **OBJECTIVES**
  - **IMPROVE SAFETY, PERFORMANCE, AND RELIABILITY OF WIRING SYSTEMS FOR SPACE APPLICATIONS**
  - **DEVELOP IMPROVED WIRING TECHNOLOGIES FOR NASA FLIGHT PROGRAMS**
- **APPROACH**
  - **IDENTIFY REQUIREMENTS/NEED FOR FUTURE NASA PROGRAMS**
  - **CHARACTERIZE EXISTING SYSTEMS**
  - **DEVELOP QUALIFICATION TEST METHODS AND STANDARDS**
  - **DEVELOP DATA TO SUPPORT CERTIFICATION**
  - **TRANSFER TECHNOLOGY TO NASA FLIGHT PROGRAMS**

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NASA WORKSHOP ON WIRING FOR SPACE APPLICATIONS

- MEETING TOPICS
  - NEAR-TERM NASA SPACE MISSIONS AND WIRING REQUIREMENTS
  - EXISTING CANDIDATE WIRING SYSTEMS
  - DATA BASE ON EXISTING CANDIDATE WIRING SYSTEMS: COMPLETENESS, CERTIFICATION AND ADDITIONAL NASA UNIQUE TESTS
  - LONG-TERM NASA SPACE MISSIONS AND WIRING REQUIREMENTS
  - WIRING TECHNOLOGIES UNDER DEVELOPMENT
  - NASA UNIQUE TESTING REQUIREMENTS
  - TECHNOLOGIES WHICH MAY SUPPORT FUTURE REQUIREMENTS, I.E. ADVANCED PROTECTION CIRCUITRY

- PLANNED ACTIVITIES
  - NASA WORKSHOP ON WIRING FOR SPACE APPLICATIONS – JULY 1991
    - NASA REQUIREMENTS
    - STATUS OF CURRENT WIRING TECHNOLOGY
    - IDENTIFICATION OF REQUIRED NASA PROGRAM EFFORTS
  - FORMULATE APPLIED TECHNOLOGY PROGRAM TO ADDRESS NASA NEEDS – NEAR TERM AND FAR TERM – AUGUST/SEPTEMBER 1991
  - REVIEW/APPROVE PROGRAM PLAN – OCTOBER 1991

- AEROSPACE WIRING SYSTEM PROGRAM ($K)

FY 91	FY 92	FY 93	FY 94	FY 95	FY 96
80	320	450	700	650	450