UNITED STATES ATOMIC ENERGY COMMISSION

LOCKHEED AIRCRAFT CORPORATION, DOCKET NO. 50-172

AND THE GENERAL SERVICES ADMINISTRATION, DOCKET NO. 50-176

NOTICE OF ISSUANCE OF FACILITY LICENSE AMENDMENT

Please take notice that, no request for a formal hearing having been filed following publication of the notice of proposed action in the Federal Register, the Atomic Energy Commission has issued, effective as of the date of issuance, Amendment No. 6 to Facility License No. R-86. The amendment authorizes Lockheed Aircraft Corporation to perform irradiation experiments involving the use of liquid hydrogen in close proximity to the Radiation Effects Reactor located in Dawson County, Georgia.

The amendment as issued was substantially as set forth in the Notice of Proposed Issuance of Facility License Amendment published in the Federal Register October 3, 1964, 29 F. R. 13623, except that for clarification purposes, Table J 1 of the Technical Specifications was modified by replacing safety trip levels with allowable operating ranges.

FOR THE ATOMIC ENERGY COMMISSION

Director
Division of Reactor Licensing

Dated at Bethesda, Maryland
this day of November, 1964

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ADDENDUM NO. 1 TO APPENDIX "A", TECHNICAL SPECIFICATIONS

LICENSE NO. R-86, AS AMENDED AMENDMENT NO. 6

Add new paragraph 3 to Section J. "EXPERIMENTAL FACILITIES", as follows:

3. Liquid Hydrogen Experiments

Subject to the following conditions, irradiation experiments involving use of liquid hydrogen (LH_2) may be conducted utilizing liquid hydrogen and auxiliary equipment mounted on RER test cars.

a. Design Requirements For Liquid Hydrogen Equipment

(1) All experimental equipment which contains LH_2 shall be mounted on a single test car and shrouded by an aluminum capsule. Leakage from this test car - capsule containment to the RER building shall not exceed 10 scfm of gaseous hydrogen for LH_2 spills of 125 gpm or less. The capsule shall be designed for an internal pressure of at least 5 psig and shall be provided with a poppet valve and a rupture disc installed in parallel which relieve to a 10-inch relief line. The poppet valve shall be set to open at a pressure of 12 inches of water or less and the rupture disc shall be rated to burst at 3 psig.

(2) The inner container of the 1000 gallon storage Dewar shall be designed for an internal pressure of at least 75 psig and the outer container shall be designed for an internal pressure of at least 60 psig.

(3) The test tank shall be designed for an internal pressure of at least 50 psig.

(4) The storage Dewar and the test tank shall be bolted to the test car and shall be capable of withstanding a 2g load in any direction.

(5) The test article, located in the test tank, shall have a maximum volume of 75 gallons and shall be designed for an internal pressure of at least 50 psig. This container shall have a siphon break in its fill line.

(6) LH_2 transfer lines, vent lines and control valves shall be designed for an internal pressure of at least 100 psig.

(7) All isolable portions of the system which normally contain LH_2 or could contain LH_2 as a result of leakage shall be protected by pressure relief valves and/or rupture discs set to relieve below system design pressure and having

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sufficient capacity to prevent overpressurization if vacuum insulation is lost. Relief lines shall join a common header inside the capsule and shall vent through a single 3-inch pipe penetration in the capsule.

(8) The 3-inch vent line shall pass over the rear of the primary test car and shall mate (through a quick disconnect) with a 3-inch vent line outside the reactor building. This 3-inch vent line, in turn, shall vent to the atmosphere at least 15 feet above the reactor building roof, and the line shall be provided with a valve which shall prevent any backflow of air into the line.

(9) A 10-inch vent line shall be provided which shall mate with the capsule vent line (through a quick-disconnect) and shall discharge to the atmosphere at least 15 feet above the reactor building. A valve shall be provided at the exit of this line to prevent backflow of air into the line.

(10) A mechanical car puller shall be provided to effect remote removal of the test car from the reactor building. Two sets of controls for the car puller shall be provided; one set within the operations building and one beside the door of the reactor building. The car puller controls located in the operations building shall not be capable of moving the test car into the building. Interlocks shall be provided to prevent removal of the test car from the building if:

(a) the hydrogen concentration in the capsule is greater than 2.5%,

(b) the reactor is operating and above the surface of the pool,

(c) electrical mating boards on the reactor building are energized,

(d) the "fail-open" vent valves are not closed for the disconnect operation.

b. Instrumentation and Safety Systems

During the course of any irradiation experiment, sufficient instrumentation shall be kept in service to permit the test engineer to monitor the condition of all portions of the experimental equipment from the operations building.

The conditions specified in Table J-1 shall cause the reactor to automatically scram and be lowered into the reactor pool. Continuous control room read-out of the minimum instrumentation indicated in the table shall be maintained at all times during an irradiation run.

c. Operating Limitations

(1) Helium shall be used for valve actuation and for inerting and pressurization operations. The helium supply shall contain no more than 8 ppm oxygen.

(2) Whenever experimental equipment containing LH_2 is in the reactor building, at least two of the reactor building roll doors shall be fully open, all reactor building roof fans shall be operating, and the reactor building basement ventilation system shall be off.

(3) All irradiation experiments shall be located in the test article. No experiments which involve moving parts or more than trace quantities of substances which may react chemically with hydrogen shall be performed.

(4) When experiments are being conducted in the RER building with liquid hydrogen, the lithium hydride shield will be removed from the support structure and will be placed near the southwest wall of the RER building. During periods that the liquid hydrogen equipment is present in the RER building, the pressure in the lithium hydride shield will be continuously monitored. Should a drop in pressure indicative of a shield leak occur, the reactor will be shut down and lowered into the pool and the liquid hydrogen experiment will be shut down and removed from the reactor building.

(5) The Liquid Hydrogen Test Engineer shall have the authority to order the reactor shut down if in his opinion a condition exists which might compromise safety.

(6) Leak rate of the capsule shall be verified to be less than one standard cubic foot per minute of Helium at 0.25 psig prior to each irradiation test.

(7) One thermocouple located in the top of the 3-inch vent stack shall provide a continuous readout in the control room and shall initiate an alarm if the indicated temperature reaches 660°F. Upon such alarm the reactor shall be manually shut down and lowered into the pool.

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TABLE J-1

Sensor	Location	Minimum Required	**Operating Range
Thermocouple	3" vent quick disconnect	1	410°R to 660°R
"	Top of 10" vent stack	1	410°R to 660°R
Hydrogen Gas Analyzer	Within Capsule	2	less than 3.5% H_2 by volume
Hydrogen Gas Analyzer	3" vent quick disconnect	1*	less than 1.5% H_2 by volume
Pressure Transducer	Supply Dewar	1	less than 65 psig
"	System pressurization manifold downstream of regulator	1	less than 190 psig
"	Valve actuation helium manifold upstream of regulator	1	greater than 130 psig
"	Test article	1	less than 65 psig
"	Capsule	1 1	2 in. w. g. to 16 in. w. g.
"	Capsule helium supply manifold, a) upstream of regulator b) downstream of regulator	 1 1	 greater than 500 ps less than 220 psig

*May be off the line for short periods of time to permit recalibration.

** The reactor shall be automatically scrammed and lowered into the pool whenever any of the parameters deviates from the specified operating range.

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(8) No irradiations involving utilization of LH_2 shall be conducted without prior approval of the irradiation by the Reactor Safety Committee.

) Irradiations involving utilization of LH_2 shall be conducted with detailed check lists and procedures which have been approved by the operating organization and the Reactor Safety Committee.

(10) Prior to initiation of an irradiation run the LH_2 equipment will be checked out in place to verify that the capsule and 10-inch vent line are properly inerted, that instrumentation reads out properl, in the operations building and that the system can be adequately controlled from the operations building.

(11) Transfer of LH_2 to the experimental equipment shall be performed only at the LH_2 Test Facility.

(12) All LH_2 to be used in the experiment shall be filtered through a 10 micron filter.

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HAZARDS ANALYSIS BY THE TEST AND POWER REACTOR SAFETY BRANCH

DIVISION OF REACTOR LICENSING

IN THE MATTER OF

LOCKHEED AIRCRAFT CORPORATION

RADIATION EFFECTS REACTOR

DOCKET NO. 50-172 Amendt #6.

By application dated December 19, 1963, and supplements dated May 28, June 4, June 16, June 22, and September 21, 1964, Lockheed Aircraft Corporation requested authority under Facility License R-86 to utilize liquid hydrogen in connection with irradiation experiments at the Radiation Effects Reactor (RER). The proposed experimental program is oriented primarily toward determining the behavior of various inert and non-moving materials under irradiation at liquid hydrogen temperatures.

Following review of Lockheed's proposal, the Advisory Committee on Reactor Safeguards stated in its letter dated July 15, 1964 that "...if planned tests of capsule integrity under large hydrogen leaks from the test tank are successful, the liquid hydrogen cooled irradiations can be performed as proposed without undue hazard to the health and safety of the public."

EXPERIMENT DESIGN

The liquid hydrogen equipment to be used in the proposed experiments will be mounted on an RER test car and will be placed in the reactor building adjacent to the reactor during each irradiation test. Another car, coupled to the test car, will contain gaseous helium in storage bottles to be used for valve operation and for pressurization and inerting operations.

The basic apparatus consists of a 1000 gallon supply Dewar mounted in the middle of the test car, and a test tank located on the forward end of the car. The test article, a smaller tank containing liquid hydrogen and an experiment, is located within the test tank and is connected to the supply Dewar by piping. A liquid level gage is provided within the test article to provide continuous monitoring of liquid hydrogen level. The supply Dewar and the test tank, with their associated piping, provide double containment for the liquid hydrogen at all points except for short sections of the pressure relief piping between the pressure relief valves and the primary system wall, and a short section of flexible line adjacent to the test tank. Vent lines from the supply Dewar and the test article are provided with pressure control valves to permit venting of gaseous hydrogen produced by normal boiloff of the liquid hydrogen during operation. These vents connect to a 3-inch line that discharges outside and above the reactor building. The control valves are designed to fail in the open position; however, they are installed in parallel with relief valves and rupture discs so that control failure will not prevent pressure relief. The dry volumes of the test tank, the storage tank and evacuated pipe jacketing, as well as

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potentially isolable sections of pipe between valves are protected by relief valves and/or rupture discs which also discharge to the 3-inch vent line.

An aluminum cover, called the "capsule", which is gasketed and bolted to the car deck, serves as a final barrier against escape of hydrogen into the reactor building should the test apparatus develop a leak. The capsule is protected from overpressure by a relief valve and a rupture disc which are installed in parallel and connected to a 10-inch vent line that discharges outside and above the reactor building. This relief system is designed to safely discharge the gas which would result from an accidental spill of liquid hydrogen into the capsule at a rate of 125 gallons per minute (gpm). During the course of an irradiation experiment an inert helium atmosphere will be maintained in the capsule and in the 10-inch vent line.

Thermocouples and pressure transducers are the basic instrumentation to be used for monitoring the experiment. Thermocouples within the capsule and in and near the vent stacks will provide a basic means for leak detection by indicating the presence of cold hydrogen gas or the presence of a hydrogen fire, depending on the location. In addition, four hydrogen gas analyzers will be provided (3 within the capsule and one outside the three-inch vent line) to detect any leakage from the experiment. Additional thermocouples, together with pressure transducers, will provide the operators with information needed for control of the experiment during an irradiation run. All thermocouples and pressure transducers will have high and/or low alarms as appropriate.

Normal control of the experiment will be performed manually by an operator in the RER control room. However, the following off-normal experimental conditions will cause the reactor to be scrammed and lowered into the pool automatically:

(1) hydrogen leakage from the joint connecting the 3-inch vent line to the experiment,

(2) hydrogen concentrations in the helium atmosphere of the capsule which approach the minimum flammable concentration of hydrogen in air,

(3) excessive hydrogen flow through the 3-inch vent line,

(4) high or low temperature conditions indicating fire or excessive amounts of hydrogen in the capsule vent line,

(5) high or low pressure within the capsule,

(6) high or low pressure in the helium supply system, and

(7) high pressure within the liquid hydrogen system.

ANALYSIS

The primary hazard associated with the proposed experiments originates from the possibility that leakage of hydrogen could lead to accumulation of explosive mixtures in the reactor building. If a detonation were to occur, it is conceivable that the reactor might be severely damaged. Accordingly, we have examined the experiment in detail to assure that adequate precautions have been taken in the design to minimize the probability of leaks and to assure that, in the event of leaks, the hydrogen could be adequately vented outside the building.

Essentially all the experimental apparatus is doubly contained by the vacuum jacket on the supply Dewar and piping, and by the test tank within which the test article is placed. The entire primary system has a nominal working pressure of 50 psig. Individual components were designed for pressure varying between 50 and 100 psig at liquid hydrogen temperatures, and were proof tested at approximately 50 psig greater than design pressure at ambient temperature. The applicant has selected materials and components, such as valves, to specifications normally used in accepted cryogenic practice.

The design of the pressure control and relief system on the experiment with respect to location, backup and capacity has been reviewed in detail. All tanks and isolable sections of piping have separate relief valves and/or rupture discs. With respect to relief capacity, it appears that the system would be limited to safe pressures under all anticipated normal and abnormal conditions. For example, the system will vent adequately even in the event of a loss of vacuum insulation. All secondary volumes, such as vacuum jackets and the test tank, are equipped with relief devices which appear to have adequate capacity to discharge hydrogen to the vent header at the boil off rate that would be anticipated following a gross leak of the primary barrier. It is unlikely, therefore, that a leak into the vacuum jacket or the test tank would lead to their failure due to excessive pressure. Furthermore, the experimental program is limited to the irradiation of passive parts, and no tests involving vibration or rotation of specimens, or involving the potential for off-gassing chemically reactive substances will be conducted. It is unlikely, therefore, that failure of an experiment would lead to leakage of hydrogen from the apparatus.

Although it appears that the applicant has taken adequate precautions in designing the experiment to prevent leaks, experience to date in the handling of liquid hydrogen indicates that leaks from the apparatus into the outer aluminum capsule cannot be ruled out. We have therefore examined the capability of the capsule to retain its integrity and to safely vent the hydrogen that would be evolved if gross leakage from the experiment were to occur. The applicant's calculations, with which we concur, indicate that the vent system can relieve the capsule at a rate sufficient to prevent overpressurizatio if hydrogen were spilled from the experiment at the estimated maximum flow rate (125 gpm) for a double-ended rupture of the liquid hydrogen transfer line. In view of the design of the system we regard this to be the largest credible leak that could occur. Spillage of liquid hydrogen at this rate could subject some portions of the envelope formed by the capsule and car deck to relatively severe thermal stress conditions. However, analysis of the structure indicates that no structural failures are likely to occur and that gasketed joints are adequately insulated against sudden temperature changes. It is not anticipated therefore that significant hydrogen leakage would occur during the period of venting following such a spill.

To confirm the integrity of the enclosure described by the capsule and test car and to confirm the ability of the capsule relief system to vent properly, the applicant will conduct an LH_2 spill test at a site remote from the reactor. The test will consist of dumping LH_2 on the test car floor at the rate of 125 gpm to simulate the maximum credible spill which could occur from a double-ended pipe break. To be successful the test must confirm the adequacy (1) of the relief system to limit the overpressure and (2) of the enclosure to limit the leakage rate to 10 standard cubic feet per minute immediately following the spill. A leak rate of this magnitude would not permit accumulation of hazardous quanitities of hydrogen in the building because of the rapidity with which hydrogen diffuses in air. Consequently, the test should demonstrate the ability of the system to safely dispose of hydrogen that might be spilled during an irradiation run. The applicant, the staff and the ACRS have recognized that the experimental program covered by the proposed amendment should not be authorized unless this test program proves successful. Accordingly, the proposed license amendment will not be issued until the result establish the required capsule integrity. If, after inspection of the test results by the regulatory staff, the test is found successful, the license amendment may be issued.

Although it is believed that the equipment has been designed in such a manner that release of significant amounts of hydrogen into the reactor building will be a very remote possibility, we have examined the possible consequences of such a release. If the capsule pressure devices should fail to open following the maximum credible spill described above, the capsule would rupture in about seven seconds. Under these circumstances, the reactor could not be lowered into the pool in time to afford protection against possibl blast effects should the hydrogen be ignited. In the worst instance, detonation of the hydrogen might occur, although it is our opinion that rapid burning (deflagration) is far more likely since the applicant has taken all reasonable precautions to eliminate potential detonation sources within the building. However, some uncertainty exists due to the fact that the effect of a radiatio field on detonation sensitivity is unknown. Consequently, the applicant has analyzed the consequences of a detonation of the entire hydrogen inventory (1000 gallons) within the reactor building with the reactor in an elevated position. This analysis indicates that the reactor would not experience significant crushing or overturning forces. Our independent analysis indicates that the overpressure associated with a detonation of this amount of hydrogen would probably cause severe damage to the reactor building and that it might cause some slight deformation of the reactor pressure vessel. However, we woul not expect the explosion to cause damage to the reactor pressure vessel, its associated piping, or the lift structure to the extent that scram capability would be impaired or reactor cooling capability would be lost before the react is lowered into the pool. Accordingly we have concluded that fuel would not melt and that a significant release of fission products is unlikely even under these extreme circumstances. It is probable that minor quantities of radioactive materials produced external to the reactor by neutron activation would become air-borne as a result of the explosion, but the hazard to persons offsite from this source would be negligible. Although the proposed experiments will slightly increase the probability of minor releases of radioactivity, we have concluded that the potential hazards to the public resulting from the proposed experiments would be no greater than those considered and found acceptable in review and approval of previous operations of the RER.

TECHNICAL SPECIFICATIONS

Proposed technical specifications for the liquid hydrogen experiments, submitted by the applicant, were modified as a result of discussions with the applicant. A copy of the modified technical specifications is attached.

CONCLUSION

Subject to successful completion of the hydrogen spill test and to the limitations set forth in the modified technical specifications, we have concluded that the proposed liquid hydrogen experiments can be carried out without undue risk to the health and safety of the public.

Original Signed by

S. Levine

Saul Levine, Chief
Test & Power Reactor Safety Branch
Division of Reactor Licensing

Date: OCT 2 1964