February 16, 1962

From Lewis
To NASA Headquarters
Attention: Washington DC
Dr. Herman Gerstein [?]

Subject: Turbopump and Nuclear Rocket Systems Evaluations to be Made in the NASA Lewis B-1 Facility
Reference: Telephone request by Mr. Gerstein [?] to Mr. Povolny for program information on February 2, 1962

1. These evaluations will include parametric studies of the significant variables affect in nuclear rocket propellant system performance. Full-scale simulation of several nuclear rocket cycles (hot gas bleed and heated gas bleed) will be made and realistic hardware will be used whenever practiceable. (Analog simulations will be made where actual hardware cannot be used.) Some of the realistic propellant system hardware items to be employed include (a) turbopump, (b) nozzle, (c) reflector, (d) reactor core (without fuel), (e) piping and valves, (f) tank outlet, (g) control system, (h) possibly a boost pump and shield. Various startup modes and control techniques will be employed during the simulation phase of the program. Steady state performance evaluations of the components (primarily pump and turbine) wil also be made. Information pertinent to the component pressure drops, heat transfer characteristics, bootstrap capabilities, flow instabilities, and control characteristics will be obtained. In general, liquid hydrogen will be supplied to the pump and unheated gaseous hydrogen to the turbine. For several evaluations, however, the turbine will be driven by gaseous nitrogen (low speed region) and by H-) combustion products (rated conditions regions). The initial program will be concerned only with the flow regime pertinent to NERVA (3lb/sec and 8.0 psia pump outlet pressure [?]). Later programs will be directed at the Phoebus flow regime.

2. The first investigation will be concerned with __ -type hot gas bleed system start up transients. This phase of the initial ___ be run with liquid hydrogen in the pump and unheated gaseous hydrogen in the turbine. It will include performance evaluations at zero flow (blocked rotor), windmill (chilldown), and turbine bootstrap, as well as conditions in between. ____ flows up to 20 lb/sec and speeds up to 6800 rpm will be encountered. The effects of system resistance, tank pressure, chilldown time, core presoak temperature, valve ramping and system management as system dynamics and starting characteristics will be determined.

If a stall problem is encountered pump by-pass will be employed to eliminate the difficulty. This investigation will be conducted on a simulated nuclear rocket propellant system employing a Rocketdyne Mark IX turbopump, a Kiwi B nozzle, a Kiwi B pressure vessel, core, and reflector, flow system valves and controls. Both triple outlet and single outlet pump volute will be used in this investigation. Approximately 60 runs will be required for this program which is expected to extend from January to May of 1963.

3. The next investigation will consist of steady state mapping of the Mark IX pump (with single outlet volute) and turbine including cavitation and stall characteristics of the pump. Data will be obtained over ranges of speeds up to 26,000 rpm and flows up to 73 lb/sec. Liquid nitrogen in the pump and unheated gaseous nitrogen in the turbine will be employed at speeds up to 14,000 rpm. At speeds above this, liquid hydrogen will be used in the pump and unheated gaseous hydrogen in the turbine. The final phase of this investigation will consist of an evaluation of the pump stall characteristics with cavitation and also operation of the turbine at rated gas temperature. Approximately 60 runs will be required for this program which is expected to run from July to December of 1963.

4.The following investigation will be similar to that of paragraphs 2 and 3 except that the Aerojet turbopump and nozzle would be used instead of the mark IX pump and Kiwi nozzle. Firm scheduling of this investigation is, of course, contingent upon the availability and status of the Aerojet turbopump.

5. Future investigations being planned, but not yet scheduled are as follows:

(a) An investigation similar to that of paragraph 2 with the addition of a boost pump ahead of the main pump.
(b) An investigation similar to that of paragraph 3 except will cover speed ranges from 26000 to 34,000 vpm without a boost pump and the full speed range (0 to 34,000 rpm) with a boost pump.
(c) An investigation similar to that of paragraph 2 except it will employ an electrically heated reflector, an analog replacement of the core and maximum flows up to at least 40 lb/sec.
(d) Additional investigations being given consideration involve shutdown transients, after heat propellant system requirements, tank heating experiments, steady state control system evaluations of systems employing pumps (both centrifugal and axial) in parallel.

6. In general, all investigations will require at least a four month hardware procurement lead to allow for instrumentation, calibration, check out, interface connections, installation, etc.

7. The above information was compiled by Mr. John H. Povolny, Assistant Cheife, Nuclear Propulsion Branch, Advanced Development and Evaluation Division.

Bruce T. Lundin

Eugene Manganiello

Files

FEB 16 1962

[illegible] Lewis
[illegible] [illegible] [illegible], [illegible]
[illegible]

Subj: [illegible]

Ref: [illegible]

1. [illegible] will [illegible] studies of [illegible] components. [illegible] will be used [illegible] practicable. [illegible] valves, (f) tank outlet, [illegible] techniques will be employed [illegible] simulation [illegible] performance evaluations [illegible] will also be made. Information [illegible] characteristics, [illegible] capabilities, [illegible] stabilities, and [illegible] characteristics will be obtained. In general, liquid [illegible] will be supplied to the [illegible] unheated [illegible] hydrogen [illegible] several [illegible], however, the turbine will [illegible] (low speed [illegible]) [illegible]. The initial program will be concerned only with the [illegible] to [illegible] 3 lb./sec. [illegible] 0 [illegible]. Later programs will be [illegible].

2. The first investigation will be [illegible] components. [illegible] very [illegible] will include [illegible] in between. [illegible] to 2 [illegible] lb./sec. [illegible] speeds up to 6,800 rpm will be [illegible]. The effects of [illegible] resistance, tank pressure, [illegible] temperature, [illegible] characteristics will [illegible].

If a stall problem is encountered pump by-pass will be employed to eliminate the difficulty. This investigation will be conducted on a simulated nuclear rocket propellant system employing a Rocketdyne Mark IX turbopump, a Kiwi B nozzle, a Kiwi B pressure vessel, core, and reflector, flow system valves and controls. Both triple outlet and single outlet pump volute will be used in this investigation. Approximately 80 runs will be required for this program which is expected to extend from January to May of 1963.

3. The next investigation will consist of steady state mapping of the Mark IX pump (with single outlet volute) and turbine including cavitation and stall characteristics of the pump. Data will be obtained over ranges of speeds up to 26,000 rpm and flows up to 73 lb./sec. Liquid nitrogen in the pump and unheated gaseous nitrogen in the turbine will be employed at speeds up to 14,000 rpm. At speeds above this, liquid hydrogen will be used in the pump and unheated gaseous hydrogen in the turbine. The final phases of this investigation will consist of an evaluation of the pump stall characteristics with cavitation and also operation of the turbine at rated gas temperature. Approximately 60 runs will be required for this program which is expected to run from July to December of 1963.

4. The following investigation will be similar to that of paragraphs 2 and 3 except that the Aerojet turbopump and nozzle would be used instead of the Mark IX pump and Kiwi nozzle. Firm scheduling of this investigation is, of course, contingent upon the availability and status of the Aerojet turbopump.

5. Future investigations being planned, but not yet scheduled are as follows:

(a) An investigation similar to that of paragraph 2 with the addition of a boost pump ahead of the main pump.

(b) An investigation similar to that of paragraph 3 except it will cover speed ranges from 26,000 to 34,000 rpm without a boost pump and the full speed range (0 to 34,000 rpm) with a boost pump.

(c) An investigation similar to that of paragraph 2 except it will employ an electrically heated reflector, an analog replacement of the core and maximum flows up to at least 40 lb./sec.

(d) Additional investigations being given consideration involve shutdown transients, after heat propellant system requirements, tank heating experiments, steady state control system evaluations of systems employing pumps (both centrifugal and axial) in parallel.

•

•

BRUCE T. LUNDIN

Copies to: ~~NASA HDQ -~~2
Code R
Col Schmidt
Carl Schwenk
Harold Finger
Deputy Director
Files
AD & E Division
H. H. Ellerbrock
J. H. Povolny