Data Storage Transmittal - 97

DATA NO. 620P-04 *	DATA TITLE FULFILLMENT OF PROJECT 620 WORK				
MEMO N8500:MD09	STATEMENT NO. 4 MILESTONE				
PROJ. NO. 620	PAR. NO. f 04	CAT. NO. 4J	NO. OF PAGES 2	PROJECT MGR. LA. SHURLEY	GRS. MGR.

BACK-UP DATA: IDENTIFY TYPES INCLUDED IN PACKAGE ALL CORRESPONDENCE REFERENCED IN THE MEMO PREPARED IN FULFILLMENT OF THIS WORK STATEMENT ARE INCLUDED IN THE DATA PACKAGE.

BRIEF DESCRIPTION OF DATA PACKAGE

THE MEMO DOCUMENTS THE INTERFACE COORDINATION BETWEEN ANSC AND WANL THAT LED TO THE RESOLUTION OF THE LOCATION OF THE FORWARD IMPEDANCE SEAL RING, PROVIDING A MEANS TO COOL THE CLOSURE BOLTS, IF REQUIRED. IT ALSO DOCUMENTS THE COORDINATION THAT RESULTED IN THE SELECTION OF A MUTUALLY ACCEPTABLE CONCEPT OF STRUCTURALLY SUPPORTING THE REACTOR AT THE FORWARD END.

* Ref Press. Vessel Des. Rept # N8500:72-R-021-096

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TID/SNA -- 2076

AEROJET NUCLEAR SYSTEMS COMPANY
SACRAMENTO, CALIFORNIA

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TO: G F Mader DATE: 26 January 1972
FROM: L A Shurley DWT:rk:N8500:M009
SUBJECT: Fulfillment of Project 620 Work Statement No. 4 Milestone
DISTRIBUTION: W E Campbell, J J Stewart, D W Tracy, P P Ventura
REFERENCE: (a) Letter SBD:JJF, R W Schroeder to E D Ward, dated May 1971
Subj: "Technical Directive No. 71-20"
✓(b) Letter N8500:L1431, G F Mader to R F Dickson, dtd 9 December 1971
Subj: "Forward Reactor Support Design Concept"
(c) Letter SA-158-71, R F Dickson to J L Dooling
Subj: "Forward Reactor Support Design Concept (IED-017)"
✓(d) Letter N8640:062L, G F Mader to R F Dickson
Subj: "Forward Reactor Support Design Concept (IED-017)"
✓(e) Letter N8640:063L, G F Mader to R W Schroeder,
Subj: "Relocation of NSS Forward Impedance Ring (Seal)"

Project 620 Work Statement No. 4 covers the activity of interface coordination between the Pressure Vessel Design Group and WANL. The work statement milestone, due 1 February 1972, was to coordinate the relocation of the forward impedance ring with WANL and provide an agreeable design concept utilizing the pressure drop across the impedance ring to cool the forward closure bolts. This milestone was incorporated into Project 620 work statements as the results of Item 20 of TD 71-20 (Reference (a)).

In trying to resolve this interface, the unidentified forward reactor support method presented a problem. Inasmuch as these two interfaces were inter-related, the resolution of both were undertaken as one problem. WANL supplied a conceptual drawing (940J511 N/C) presenting their design concept. ANSC reviewed this drawing and was in agreement with the approximate relocation of the forward impedance ring; however, could not accommodate the suggested forward reactor support concept in the ANSC hardware. Four alternate concepts were prepared and submitted to WANL for review and comment in Reference (b). WANL reviewed these proposed concepts and transmitted the results of their review in Reference (c); in which they made a concept selection and provided justification for their selection. As this selection was agreeable with ANSC, Reference (d) was prepared stating agreement with the concept selection and that the PVC/NSS interface definition and hardware design would proceed on this basis.

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Unclassified	
CLASSIFYING OFFICER	DATE
A. Shurley	1/27/72

With these agreements between WANL and ANSC on interface definition of the forward reactor support and forward impedance ring location, which provides a method of cooling the forward closure bolts, the work statement milestone is considered fulfilled. This design concept agreement also fulfilled Action Item No. 20 of TD 71-20 and a letter to Mr. Schroder (Reference (e)) informing him of fulfillment has been published.

L. A. Shurley, Manager
Nozzle, Pressure Vessel
and Skirt Department
Engineering Operations

SPACE NUCLEAR SYSTEMS OFFICE
CLEVELAND EXTENSION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
21000 BROOKPARK ROAD, CLEVELAND, OHIO 44135

In reply refer
to SDB:JJF

27 May 1971

Mr. E. D. Ward
Vice President and General Manager
Aerojet Nuclear Systems Company
Aerojet-General Corporation
P.O. Box 13070
Sacramento, California

SUBJECT: TECHNICAL DIRECTIVE NO. 71-20

Dear Mr. Ward:

Pursuant to Clause 60 of the General Provisions of Contract SNP-1 entitled, "Technical Direction", the technical direction set forth below is hereby conveyed to the contractor.

At the closing session of the Engine/Component Design Status Review (E/CDSR) meeting during the week of May 10, 1971, the Government verbally summarized the resulting action items and comments. The purpose of this directive is to formally transmit the final version of the action items and comments which are attached hereto. You are hereby directed to incorporate the action items into your current work efforts and take cognizance of the comments.

It is requested that the Contractor proceed promptly with the performance of this Technical Direction and acknowledge receipt thereof, in accordance with the provisions of Clause 60, by signature of an appropriate Contractor official in the space indicated below.

Very truly yours,

R. W. Schroeder
Contracting Officer
Chief, SNSO-C

Attachment:
E/CDSR Action Items & Comments

cc: R. F. Dickson, WANL (For Info Only)
W. L. Snapp, AGC/Cleveland

RECEIPT ACKNOWLEDGED:
AEROJET NUCLEAR SYSTEMS COMPANY
BY _____
DATE _____

ATTACHMENT
E/CDSR ACTION ITEMS AND COMMENTS

I. E/CDSR Action Items - Engine Systems

- (1) Define the basis for the criteria used to establish initial and final turbopump conditions for power chill operation.
- (2) Consider drum scram at the throttle point and the use of one TPA to avoid stall during shutdown, including any safety implications.
- (3) Consider using decay power reflecting those fission products lost by diffusion during the burn. Evaluate the effect on cooldown time and impulse.
- (4) Consider an additional emergency operating point that takes into account the corrosion threshold of the core material (graphite) and other considerations such as incipient failure of nozzle tubes.
- (5) The analysis of space soak thermal effects is inadequate to support the conclusion that a coating is needed. Do not incorporate a coating requirement into the engine specification at this time. Continue limited thermal analyses, including the following:
 - a. Provide the thermal time constant of the engine in space soak condition.
 - b. Evaluate the effects of circumferential conduction to shaded sides of thrust structure, pressure vessel, etc.
 - c. Provide the effects of surface finish of pressure vessel aluminum and thrust structure titanium components on the absorptivity/emissivity ratio for sunlight.
 - d. Assess the effect of the earth's albedo.
- (6) Define a plan to preclude improper nozzle jacket/coolant channel tube assembly effects.
- (7) Update nozzle coolant channel (tube) low cycle fatigue reliability calculation based on most recent data.
- (8) Examine engine leakage requirements for long coast periods (planetary mission) with PSOV failed open. Define appropriate backup valve leakage requirements and estimate design difficulty. (Restatement of action item from April components review meeting.)

- (9) Conduct a minimal program using fracture toughness techniques to investigate the effects of aluminum flame spraying on the properties of the pressure vessel material.
- (10) Define the process and responsibility for definition, design and development of measurement systems for controls/performance malfunction detection, diagnostics and trend data. Provide for integration of flight-type instrument development into all hardware development programs.
- (11) Provide accelerometers to IASL for dynamic test in GTR-23.
- (12) ANSC must delete all bellows from high pressure lines or render all failure modes incredible. Please submit an early statement of the proposed approach.
- (13) With regard to TPA chilldown, an option appears available which should be examined. Consider the mission models which serve as the basis for the NERVA design, together with the thermal time constant information from (5) above, to determine how much heating of TPA parts actually takes place. In long soaks (maximum heating) the tank pressure chilldown appears allowable. In short soaks (minimum heating, assisted by thermal insulation of TPA and an inventory of cryogenic hydrogen left in the PFS) power chill with minimum liquid hydrogen loss appears possible. Please substantiate these possibilities. Consider normal NASA missions only without the need for unplanned, rapid startups.
- (14) The growth version thrust of 50,000 lbs. is not acceptable and the assumptions which led to its selection are questionable: For a chamber temperature of 4500°R and a thrust of 75,000 lbs., the contractor should do the following:
 - a. Re-assess the individual component reliability values for this mode of operation and compare the total engine reliability with the specified value of 0.995 and determine the resultant life capability of the engine.
 - b. If the answer in a. above is less than two hours, define the design changes required to meet the 2-hour (12 cycles) requirement.
 - c. Also define the design changes required, if any, to achieve 4-hours (24 cycles).
 - d. In addition, compliance with the criterion that no single failure has a probability greater than 10^{-8} during a 10-minute full power cycle should be assessed.

- (15) Future dynamic analysis of launch and boost operations of the main engine frame should include the configuration without the external shield. Beyond this, work based on INT-21 should be phased out as soon as possible, and input based on ECS should be used as it is made available. SNSO-C will update SNPO-C-6 for EOS, and SNSO-C personnel will work with ANSC personnel on a current basis to supply EOS data.

The dynamic analysis of NERVA full power flight loads is not adequate to support the design. Additional analysis should be conducted and problem areas requiring design solutions documented.

- (16) Determine the impact of raising the TPA malfunction requirement to 3-hours instead of the current 75 minutes.
- (17) The effect of radiation on the low cycle fatigue properties of nozzle tube material should be investigated. Mr. Lombardo of SNSO-C will initiate this action and will contact ANSC later.
- (18) A short term concept study should be started now which renders rapid closing of the PSOV incredible.
- (19) The weight penalty associated with the use of 6061 Aluminum for the pressure vessel dome is unacceptable. Please change the material to 7075 Aluminum and design it without a need for welding.
- (20) ANSC and WANL should resolve the location of the impedance ring around the reflector as soon as possible, with the objective of providing a source of hydrogen Δp for cooling the pressure vessel forward flange bolts. Other means of providing this coolant flow should also be considered.
- (21) Provide the radial and circumferential (near periphery) temperature profiles at the throttle condition, with flat temperature profiles at full power, with (a) constant drum angle, and (b) WANL recommended drum angle change.
- (22) Provide the basis for the 4378°R temperature limit on transients.
- (23) Concern has been expressed about leakage through the piston ring type seal between the concentric turbine lines and the reactor dome. There is also concern about the ability to inspect and leak test this seal. Provide an estimate of the maximum leakage that could be expected under the worst tolerance condition, and also in the case of credible failure.
- (24) Define the procedures involved with the generation, implementation and documentation of test requirements, including verification of design/reliability analysis and the incorporation of quality assurance conditions. Furthermore, in addition to test plans,

quality assurance considerations should be integrated into the reliability and design analysis and fabrication plans. Examples are: (a) means for verifying crack sizes that can be detected in components made of crack-sensitive material, (b) need for process control in production of 440-C bearings, and (c) truncation of capability distribution curve for structural materials and electronic components.

- (25) A proposed cooldown scheme requires the TPA to be carried into stall before TPA shutdown. There is concern about the behavior of the TPA stall, particularly in the possible presence of 2-phase flow. An ANSC proposed TPA test plan to investigate this problem is expected at an early date.
- (26) Nearly all the category IIIB and IV engine failures are the result of excessive external leakage, particularly leakage of lines and bellows. In addition to incorporating design features of lines and bellows to render these failures incredible, leakage detection techniques should be formulated and incorporated into the engine trend data and malfunction detection system. In other words, the strategy for detecting and handling engine external leakage during the engine operation should be devised.

II Engine/CDSR Comments - Engine System

- (1) Refine loads analyses to define more precisely the loads to the NSS.
- (2) Integrate WANL comments/concerns into the engine design/analysis activity.
- (3) There is concern about the melting and resulting containment problem with lead and the high operating temperatures of the lithium hydride in the external shield design. It is noted here to document this against the day that the shield design effort is resumed.
- (4) There have been discussions recently about a new requirement $\pm 5^\circ$ (circular pattern) for the thrust vector angle. This will be imposed as a requirement in the near future.
- (5) There are many maintainability areas that should be considered weak at present, such as electrical connectors, line connections, contamination prevention, post maintenance verification, etc.

- (6) There is concern about the single point failures in the gimbal actuators in the 400-E engine. When work is resumed on the gimbal actuators, this should receive early attention.
- (7) Your concern is recognized and shared with respect to the requirement for detection of Category II, III and IV failures and for redundancy in the I&C system. The Government is reviewing the MRL currently in effect and will correspond with you at an early date regarding its assessment.
- (8) There is concern in regard to definition of instrumentation requirements for controls. Examples of items that must be defined as soon as possible are:
 - (a) dynamic response requirement for T_c
 - (b) need for close-in location of P_c transducer.
- (9) SNSO-C has reviewed the case for the SSCA bypass orifice. It is the Government's position that the orifice shall not be incorporated at this time for the following reasons:
 - (a) The bypass orifice may be incorporated at a later date, but in order to complete analyses of the current engine configuration, the change will not be made now.
 - (b) Because of the uncertainty of a liquid hydrogen insertion problem during startup, it will be necessary to maintain the more difficult valve and actuator requirements for the no-orifice case. Therefore, the malfunction analyses for the no-orifice case must be done in any event.
 - (c) The first ground test engine should probably incorporate a bypass orifice capability. Should test results affirm the desirability for an orifice, that would be the time for incorporation.
- (10) A revised reliability statement is currently under consideration for paragraph 3.1.2.1 of the engine specification. It is expected that the ANSC proposal of a failure probability of 10^{-8} for Category IV system failure will be endorsed. Subsequent allocation of this value will inherently define allowable failure probabilities at the component and lower levels for these most critical potential failure modes. This sub-allocation process will therefore define explicitly "incredible" failure likelihoods.

DISTRIBUTION: W. E. Campbell, A. D. Cornell, J. R. DaVolio, O. J. Demuth,
(w/encl) J. L. Dooling, R. V. Evleth, U. A. Pineda, L. A. Shurley,
J. L. Smith, J. J. Stewart, D. W. Tracy, J. L. Watkins
G. F. Mader

N8500:L1431

9 December 1971

Mr. R. F. Dickson
Manager, Program Management
NERVA Nuclear Subsystem
Westinghouse Astronuclear Laboratory
Post Office Box 10864
Pittsburgh, Pennsylvania 15236

ROUTING LIST		
NAME	INITIAL	DATE
LA Shurley	LA	12/6/71
AD Cornell	AD	12/6
WE Campbell	WE	12/1
RV Evleth	RV	12/1
JL Dooling	JL	12/8/71
NA Norman	NA	12-8-71

Attention: R. L. Gelrich

Subject: Forward Reactor Support Design Concept

Reference: (a) IED-017, subject: Coordinate PV/NSS Forward End Design
(b) Letter DI:CMB:1647 from R. F. Dickson to J. L. Dooling, subj:
NERVA Nuclear Subsystem Assembly Layout, Drawing 939J740,
Rev. B and Component Layouts dated 17 June 1971

Dear Mr. Dickson:

In response to Reference (a), Reference (b) was received from WANL on 7 July 1971. A proposed location of the forward impedance ring and a design concept for supporting the NSS from the pressure vessel cylinder near the joint between the pressure vessel closure and pressure vessel cylinder (PVC/PV) were presented in this reference (WANL Drawings 940J511 and 940J553).

The proposed impedance ring location in the area at the pressure vessel forward joint is acceptable to ANSC. Furthermore, the impedance at this location provides an acceptable method (concept is shown in Enclosure (1)) of cooling the forward closure bolts, if this becomes a requirement. To date this concept has no detailed analytical backup; however, preliminary calculations show that the 10 psi pressure drop (consistent with current engine specification fluid state point data) across the impedance seal will provide a flow of approximately 1.3 lbs/sec through the bolts. This flow is adequate for bolt cooling. Diversion of the total 25 lbs/sec flow rate through the bolt coolant flow path, as previously proposed by WANL is not possible within the 10 psi pressure drop limitation.

The reactor forward support concept as shown in Reference (b) is not acceptable from the pressure vessel design standpoint because of a significant effect on the PVC/PV joint design. To accommodate a slot of 0.61 inches as defined by WANL Drawing 940J558 would require increasing the closure bolt circle diameter

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<i>[Signature]</i>	12-8-71

by approximately 0.72 inch. The bolt loading at the present bolt circle diameter is critical and preliminary analyses indicate an increase in bolt circle diameter of this magnitude would preclude structural adequacy.

Enclosure (2) presents four alternate concepts for the forward reactor support, that would not preclude structural adequacy of the PV joint design. A brief discussion of each concept is as follows:

Concept A

From discussions with WANL personnel, it was concluded that the actual slot depth required to allow the differential deflection between the pressure vessel and the support structure is not defined at this time. This concept is essentially the same as submitted by WANL, except the radial slot depth is 0.25 inch, which is the maximum slot depth that can be accommodated in the pressure vessel flange without degradation of the structural integrity of the joint. To evaluate the adequacy of this concept, the radial deflection, during operating conditions, of both the pressure vessel and the support structure are required. From preliminary analysis of the pressure vessel flange, the radial deflection at the slot locations was determined as described in Enclosure (3).

Concept B

This concept depicts a gear tooth mounted to the NSS hardware that engages the PV cylinder in slots cut between the bolts. This concept allows the 0.61 slot depth shown on the WANL concept. The concept shows a three tooth engagement at each location; however, this could be increased to any number required to react the loads.

Concept C

In this concept the radial slots are in the PV closure instead of the cylinder. This concept allows the 0.61 inch slot depth without increasing the bolt circle diameter. This can be accomplished because the closure inside diameter does not have to be maintained at 54.320 inches for assembly.

Concept D

In this concept the radial slots are shown in the NSS and the tabs are mounted on the PVC. Sufficient detail of the NSS in this area is not shown in the reference drawings to evaluate the feasibility of this concept. However, it is shown to the detail possible for your further consideration.

Another possibility of forward reactor support would be to integrate the support scheme into the NSS at the Turbine Discharge Line Interface. With the present NSS/TDL interface concept, shown on 1136393C, this concept would involve only

Mr. R. F. Dickson

-3-

WANL hardware; therefore, a concept is not presented by ANSC. However, the loads would be fed into the pressure vessel closure at TDL Port. From a preliminary look at the closure the + 3g lateral loads could be reacted at this interface. However, when this g loading is defined as interface loads, this assumption would require verification.

These concepts are submitted for your review. They may or may not meet with mutual agreement; however, sufficient information is presented to justify ANSC problems with the WANL proposed concept. Also, sufficient ANSC pressure vessel information is presented for WANL to evaluate and determine the actual slot depth required in the pressure vessel flange to allow for the differential deflection.

It is requested that WANL evaluate the information presented and submit a proposed concept to ANSC by 1 January 1972.

Please contact D. W. Tracy, (916) 355-6562, for any additional information required.

Very truly yours,

AEROJET NUCLEAR SYSTEMS COMPANY

G. F. Mader, Manager
Program Controls Department
NERVA Rocket Operations

DWT:rbk

Enclosure: (1) Forward Closure Bolt Coolant Concept
(2) Study Layout - Forward Reactor Support Concepts
(3) Pressure Vessel Flange Radial Deflection

cc: R. W. Schroeder, SNSO-C w/encl
W. C. Milstead, SNSO-C w/encl
K. E. Estes, SNSO-C w/encl
M. M. Carness, SNSO-C Rep. at ANSC w/encl
C. R. Dippel, WANL Rep. at ANSC w/encl

CLOSURE BOLT COOLANT CONCEPT

NOTES:

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES		TOLERANCES		CONTRACT NO.		DATE		TITLE	
		DECIMALS	ANGULAR						
		±.015		J.L. SMITH		11/1/71		FORWARD REACTOR SUPPORT DESIGN CONCEPTS	
		DO NOT SCALE DRAWING		CHECK		DESIGN		DESIGN ACTIVITY	
				SIMILAR TO		ACT. NO.		CUSTOMER	
				PART NO.		CALC. NO.		SCALE	
				NEXT ASSY		USED ON		RELEASE DATE	
				APPLICATION				SHEET	

PRESSURE VESSEL FLANGE RADIAL DEFLECTION

A. Steady State, EOL-Normal Design Point Conditions

From the PVC/PV joint stress analysis, now in process, the radial deflection due to pressure loading (ΔR_P) varies linearly from + .003 inch at the PV/C interface to + .024 at the aft end of the 1.75 inch slot. From the thermal analysis of the joint, the flange temperature is 310°R. The radial deflection due to temperature change is:

$$\Delta R_T = \alpha R \Delta t$$

where:

$$\Delta R_T = \text{radial deflection due to temperature}$$

$$\alpha = \text{coefficient of thermal expansion}$$

$$R = \text{pressure vessel radius}$$

$$\Delta t = \text{assembly temperature} - \text{operating temperature}$$

$$\therefore \Delta R_T = (11.63)(10^{-6})(27.160)(-220^\circ) = - .070 \text{ inch}$$

$$\begin{aligned} \text{Total } \Delta R_{PV} &= \Delta R_P + \Delta R_T \\ &\text{(at PV/C} \\ &\text{interface)} \end{aligned}$$

$$= .003 + (-.070)$$

$$= -.067 \text{ inch (INWARD)}$$

$$\begin{aligned} \text{Total } \Delta R_{PV} &= \Delta R_P + \Delta R_T \\ &\text{(at aft end} \\ &\text{of 1.75 inch} \\ &\text{slot)} \end{aligned}$$

$$= .024 + (-.070)$$

$$= -.046 \text{ inch (INWARD)}$$

B. Thrust Buildup Transient Conditions

The maximum inward radial deflection at the flange will occur during thrust buildup transient conditions when liquid hydrogen is flowing in the pressure vessel and the internal pressure is low. As transient analyses have not been conducted, the following assumptions were made to obtain the flange temperature and radial deflection:

1. The hydrogen temperature at the PV flange is 60°R. The hydrogen temperature is 50°R at the reflector inlet and 100°R at the turbine inlet; therefore, 60°R is considered a conservative (a value that will produce maximum deflection) estimate.
2. The internal pressure is zero, therefore, there is no resultant radial deflection.
3. The flange material temperature is approximately equal to the hydrogen temperature.

Then:

$$\begin{aligned}\Delta R_T &= \alpha R \Delta t \\ &= (8.88)(10^{-6})(27.160)(-470) \\ &= -.113 \text{ Inch (INWARD)}\end{aligned}$$

C. Coast Conditions

The maximum outward radial deflection of the flange will occur during coast conditions. Analysis for this condition has not been completed; however, a maximum deflection can be calculated based on the following assumptions:

1. The flange material temperature, due to solar heating, will be equal to the maximum allowable material temperature of 735°R.
2. Internal pressure will be zero.

Then:

$$\begin{aligned}\Delta R_T &= \alpha R \Delta t \\ &= (14.5) (10^{-6}) (27.160) (205^\circ) \\ &= .081 \text{ Inch (OUTWARD)}\end{aligned}$$

The radial deflection from assembly dimensions of the pressure vessel closure flange, ranges from +.081 inch during coast conditions to -.113 inch during transient conditions. With this information, in conjunction with the structural support radial deflection characteristics, an evaluation of the adequacy of the .25 inch slot depth concept can be made.

Westinghouse Electric Corporation

Industry & Defense Products

Astronuclear Laboratory

Box 10864
Pittsburgh Pennsylvania 15236
(412) 892 5600

SA-158-71

DEC 23 1971

Mr. J. L. Dooling
Manager, Subcontracts
NERVA Rocket Operations
Aerojet Nuclear Systems Company
Post Office Box 13070
Sacramento, California 95813

Attention: D. W. Tracy

Subject: Forward Reactor Support Design Concept (IED-017)

- References:
- (a) Letter N8500:L1431, from G. F. Mader to R. F. Dickson,
Subject: Forward Reactor Support Design Concept, dated
December 8, 1971
 - (b) IED-017, Subject: Coordinate PV/NSS Forward End Design

Gentlemen:

In response to Reference (a) and in fulfillment of Reference (b), a meeting of WANL cognizant personnel was held December 14, 1971, to review the above subject matter with the following results.

The proposed WANL impedance ring (seal) as accepted by ANSC will be added to the NERVA Nuclear Subsystem assembly layout when bolt cooling becomes a requirement. Analysis and modification of the peripheral shield/pressure vessel annulus for routing the remaining 23.7 lbs/sec flow through this region must be conducted. Possible solutions are slotting the PV between bolts, have impedance ring pass excess flow, or redistribute excess flow through shield. WANL recommends the first solution for consideration by ANSC.

The reactor forward support concepts as presented in Reference (a), Enclosure (2), were reviewed and the following comments made:

Concept A

This concept is not acceptable to WANL based upon ANSC preliminary analysis of the pressure vessel flange presented in Reference (a), Enclosure (3), and WANL preliminary analysis of the radial deflection of the support structure during operation, due to insufficient engagement. It therefore appears that this concept should be dropped.

Concept B

This concept is not acceptable to WANL based upon complexity of assembly and structural integrity and it is proposed that further study of this concept be terminated.

Concept C

Concept C, depicting radial slots in the PV closure with keys attached to the NSS support structure, appears feasible to WANL and warrants detailed study. Problems do exist, however, in final assembly to center the keys with the required 0.030-inch side clearance. A solution such as use of an exact ring matching the flange and slotted area of the PV closure for sizing the keys prior to final closure installation should be considered.

Concept D

This concept offers another solution acceptable to WANL for more detailed study. Assembly match up may require selective fitting of the keys at WANL to hold assembly tolerances.

A fifth concept, involving the integration of the support system into the NSS turbine discharge line interface, was suggested by ANSC. This has been considered by WANL but is an unlikely contender compared to concepts C&D due to added complexity in analysis of an already complex problem and the need to keep the fore and aft radial support points close together to minimize reactor/pressure vessel annulus close up during operation.

J. L. Dooling

- 3 -

SA-158-71

In conclusion, WANL believes concepts C or D can be made to work with preference given to Concept D. Further detailed studies can be made when funding becomes available. With this response, WANL considers the requirement of IED-017, Reference (b), satisfied.

Respectfully,

A handwritten signature in dark ink, appearing to read 'R. F. Dickson', with a stylized, cursive script.

R. F. Dickson, Manager
Program Management
NERVA Nuclear Subsystem

CMB/mhs

cc: R. W. Schroeder, SNSO-C
G. K. Sievers, SNSO-C
W. C. Milstead, SNSO-C
H. H. Hoffman, SNSO-C Rep. at WANL
C. R. Dippel, WANL Rep. at ANSC
K. E. Estes, SNSO-C

cc: WE Campbell, AD Cornell, JR DaVolio, JL Dooling, RV Evleth, GF Mader, RA Oravetz,
LA Shurley, JL Smith, WE Stephens, JJ Stewart, DW Tracy, KE Unmack, PP Ventura,
WO Wetmore

18 January 1972

N8640:062L

JLS:nd

MUST BE MAILED 1/17/72 TO MEET
ACTION FOLDER DUE DATE OF 1/17/72.

Mr. R. F. Dickson, Manager, Program Management
NERVA Nuclear Subsystem
Westinghouse Astronuclear Laboratory
P. O. Box 10864
Pittsburgh, Pennsylvania 15236

Attention: R. L. Oelrich/E. H. Hemmerle

Subject: Forward Reactor Support Design Concept (IED-017)

Reference: (a) Letter SA-158-71, R. F. Dickson to J. L. Dooling,
dated December 23, 1971, Same Subject
(b) IED-017, Subject: Coordinate PV/NSS Forward End Design
(c) WANL Drawing 939J740
(d) WANL Drawing 940J389
(e) TD 71-20 - Action Items from E/CDSR, Phase II Meeting
on May 11-14, 1971

Dear Mr. Dickson:

The timely submittal of Reference (a) is appreciated.

ANSC concurs that receipt of Reference (a) by ANSC represents satisfactory
completion of Part B of Reference (b).

WANL is requested to revise References (c) and (d) to show the forward impedance ring (seal) location $\leq$ 3.00 inches aft of the PV/PVC interface as defined on WANL Drawing 940J511 prior to submittal to ANSC as input for IED-001 (Part B) and IED-015. This action will reflect completion of an action item assigned by SNSO-C to both ANSC and WANL requesting a forward impedance ring location and interface design study to provide capability for hydrogen cooling of PV/PVC bolts (Reference (e)). IED-001 and IED-015 input by WANL should include additional dimensional interface definition currently available, though not provided by WANL Drawing 940J511, to provide a more complete interface description. The current WANL design should provide for flowing the total 25 lbs/sec of hydrogen through the PV cylinder/peripheral shield annulus. When, or if hydrogen cooling of the PV/PVC bolts becomes a requirement, a means of diverting approximately 1.3 lbs/sec of hydrogen to the bolts and flowing the remaining 23.7 lbs/sec of hydrogen through the PV cylinder/peripheral shield annulus will be devised and included in the design.

ROUTING LIST		
NAME	INITIALS	DATE
JR DaVolio	JR	1-17-72
AD Cornell	AD	1-17-72
JJ Stewart	JJ	1-18
RV Evleth	RV	1-18
JL Dooling	JL	1-18
L.A. SHURLEY	LS	1-18-72

CLASSIFICATION CATEGORY	
UNCLASSIFIED	
<i>JL Smith</i>	1/17/72
CLASSIFYING OFFICER	DATE

C-20685

ANSC agrees with the WANL conclusion that either Concept C or D, described in Reference (a), will provide acceptable reactor forward support and that Concept D is preferred.

ANSC will proceed with pressure vessel design on the basis that Concept D has been selected. WANL should proceed with necessary supplementary analyses to refine and justify this design concept consistent with the current CY 1972 program.

Very truly yours

AEROJET NUCLEAR SYSTEMS COMPANY

G. F. Mader, Manager
Program Controls Department
NERVA Rocket Operations

cc: R. W. Schroeder, SNSO-C
W. C. Milstead, SNSO-C
K. E. Estes, SNSO-C
G. K. Sievers, SNSO-C
M. M. Carness, SNSO-C Res at ANSC
C. R. Dippel, WANL Res at ANSC

cc: WE Campbell, AD Cornell, JR DaVolio, JL Dooling, RV Evleth, GF Mader, RA Oravetz, LA Shurley, JL Smith, WE Stephens, JJ Stewart, PP Ventura, GD Westcot, WO Wetmore, CAD Files

N8640:063L
JLS:nd

MUST BE MAILED 1/27/72 TO
MEET MILESTONE/ACTION ITEM
DUE DATE OF 2/1/72

Mr. R. W. Schroeder, Chief
Space Nuclear Systems Office
National Aeronautics and Space Administration
21000 Brookpark Road
Cleveland, Ohio 44135

NAME	DATE
JR DaVolio	1-25-72
AD Cornell	1-25-72
LA Shurley	1-25-72
JJ Stewart	1-25-72
RV Evleth	1-25-72
JT Paul	1-25-72

Attention: W. C. Milstead/W. H. Robbins/G. K. Sievers

Subject: Relocation of the NSS Forward Impedance Ring (Seal), TD 71-20,
Action Item No. 20

Reference: (a) Letter N8640:062L, G. F. Mader to R. F. Dickson, dated
18 January 1972, Subject: Forward Reactor Support Design
Concept (IED-017)
(b) Letter SDB:JJF, R. W. Schroeder to E. D. Ward, dated
27 May 1971, Subject: Technical Directive No. 71-20

Dear Mr. Schroeder:

Reference (a) documents completion of Action Item I(20) of Reference (b) which
states as follows:

"ANSC and WANL should resolve the location of the impedance ring
around the reflector as soon as possible, with the objective of
providing a source of hydrogen Δp for cooling the pressure vessel
forward flange bolts. Other means of providing this coolant flow
should also be considered."

The forward impedance ring and seal relocation defined in Reference (a) is
based upon the current allocation of a 10 psi hydrogen pressure drop for pro-
viding a design, if required, to enable cooling the pressure vessel cylinder/
closure bolts, as requested by the subject action item.

The impedance seal relocation will be incorporated in the next update of the
1138808 pressure vessel, 939J740 NSS layout and 1137400 Baseline NERVA Flight
Engine. This design change will simply relocate the impedance seal, but will
not include bypassing hydrogen to the bolts for coolant as this is not a
requirement at the present time.

Very truly yours,

AEROJET NUCLEAR SYSTEMS COMPANY

G. F. Mader, Manager
Program Controls Department
NERVA Rocket Operations

UNCLASSIFIED

1-25-72

Mr. R. W. Schroeder

-2-

N8640:063L

cc: M. M. Carness, SNSO-C Res at ANSC
R. F. Dickson, WANL
R. L. Oelrich, WANL
E. H. Hermerle, WANL
M. K. Wright, WANL
C. R. Dippel, WANL Res at ANSC