REON

ROCKET ENGINE OPERATIONS - NUCLEAR

REPORT NO. 2506 ADDENDUM-1
TO
AEC-NASA SPACE NUCLEAR PROPULSION OFFICE

ETS-1 FLUID REQUIREMENTS ADDENDUM

NERVA PROGRAM
CONTRACT SNP-1
JUNE 1963

MASTER

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Report No. 2506
Addendum-1

ABSTRACT

This addendum contains data concerning the ETS-1 Fluid Requirements which supplements and supersedes the data contained in Report No. 2506.

A handwritten signature in dark ink, appearing to read "W. D. Stinnett", is written over a horizontal line.

W. D. Stinnett
REON Technical Systems Manager

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Report No. 2506
Addendum-1

ADDENDUM 1

ETS-1 FLUID REQUIREMENTS ADDENDUM

The ETS-1 Fluid Requirements delineated in Report 2506 are based upon specific ground rules which define a static test facility capable of the reference test plan described in the report. If these ground rules were changed to reflect a static test facility capable of a lesser specifically defined test plan, the ETS-1 fluid requirements could be reduced. This addendum defines the minimal ETS-1 fluid requirements based on such a reduced test plan.

The ETS-1 fluid requirements and the storage capacities and system modifications imposed by these requirements are based upon the following ground rules:

- a. The existing 1770 cu. ft. gas storage vessels have a 3600 psig working pressure capability.
- b. The total quantity of useful available gas is predicated on a summer ambient temperature of 120°F.
- c. The liquid storage and use vessels will have 10% ullage immediately prior to their initial use in a test preparation and countdown sequence. This requirement minimizes transfer and pressurization gas requirements.
- d. There is no test facility turnaround requirement. The time required to make a specific test is predicated on the facility requirements, and not on the engine program schedule.
- e. Use factors, compression and collapse factors, and miscellaneous losses are the same as those utilized in calculating the requirements presented in the body of Report 2506.

Table V in the body of Report 2506 defines the ETS-1 fluid requirements, based upon the assumptions and ground rules delineated in the report. Table I of this addendum defines the ETS-1 fluid requirements, based upon the assumptions and ground rules delineated herein. The differences between the gas requirements described by the two tables is through the specific differences in ground rules as follows.

UNCLASSIFIED

Report No. 2506
Addendum-1

Report 2506 text refers to the possibility that, since the ratio of total capacity to quantity required is very large, a liquid storage or use vessel might contain sufficient liquid to make a test firing with an initial ullage much greater than 10%. Therefore, the gas requirements delineated in Table V in Report 2506 are predicated on the assumption that each liquid vessel is emptied to 90% ullage.

Table I, based on the ground rules defined above, minimizes the ETS-1 pressurization and transfer gas requirements by assuming all liquid storage and use vessels have 10% ullage immediately prior to their initial use in a test preparation and countdown.

The 10% initial ullage ground rule reduces the calculated gas requirement as indicated by a comparison of Table I of this addendum with Table V in the body of Report 2506. However, from an operational view, it is apparent that maintaining a 10% ullage in all liquid storage and use vessels as defined by this ground rule would induce several operational problems. For example, if there was any fluid use requirements that were not anticipated, leakage, loss through excessive heat gain, or any similar unplanned loss of use, it would be necessary to stop the preparations and countdown to top off the involved liquid vessel to 10% ullage again, and recharge the associated gas bottles. Since the time loss through topping of a single vessel would probably require repeat of a portion, or all of the preparation and countdown, it would probably be necessary to top off the other liquid vessels at the same time.

Holds over extended periods during the countdown procedure might require venting and repressurization of some vessels. This would require recharge of the associated gas system under these minimal conditions. Transfer of the LH_2 from the run tank back to the storage dewar to facilitate a hold condition would necessitate recharging of the pressurization gas supply, and topping of the LH_2 storage dewar prior to reinitiation of the countdown. The time involved in recharging and topping operations will usually necessitate starting the countdown at some earlier point because of the calibration and checkout duration limitations.

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Report No. 2506
Addendum-1

Another alternative to the recharge and topping requirement would be to evaluate, immediately prior to a test firing, the status of the propellant and process system and base the run duration on that status. Each test duration would vary with the facility capability at the time of that run with a maximum duration of 300 seconds possible. To provide the maximum possible duration of tests under facility predicated conditions would require a continuous computer program which would indicate maximum test duration at any time based upon automatic facility status input from facility instrumentation feedin.

Although the ETS-1 fluid requirements defined in Table I are such that either test turnaround time or engine test firing duration cannot be determined prior to test, the requirements do minimize the modifications and additions to the propellant and process fluid systems.

In accordance with Table I no additional gaseous hydrogen storage is required. The required quantity of GH_2 is 4,040 lbs and the available quantity is 4,545 lbs.

The available quantity of gaseous nitrogen is 44,200 lbs, or less than the 51,510 lbs of GN_2 that are required. Additional GN_2 total storage capacity or additional low pressure GN_2 supply capacity for engine compartment inerting and steam generator system purge is required. As an alternate to additional storage bottles, a low pressure vaporizer with a pressurized supply system could be utilized to supply low pressure purge gasses.

The available quantity of gaseous helium is 3,040 lbs, or less than the 4,970 lbs that is required. Additional capacity is mandatory.

The minimum time required for recharge of ETS-1, following a 300-second duration, full power test, utilizing the existing equipment, is 8.2 days. Since the current ground rules indicate that the turnaround time can be dictated by the facility, there is no need to make any additions or modifications to ETS-1 in order to increase the recharge capability.

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TABLE I

ETS-1 FLUID REQUIREMENTS

Fluid	Purpose	Quant. Req'd (lbs)	Temp. and Pressure	Total Useful Available (lbs)	Post Test Recharge Time	Remarks
Liquid Hydrogen	Engine Test Fluid	42,000	25-50 psia at -423°F	42,000	1 hour	Fill from storage vessel prior to test.
	Emerg. Cooldown	2,400	700 psia at 423°F	2,400	1 hour	Fill from storage vessel prior to test.
	Loss to Chill Run Tank	10,000	-			
	Loss to Chill Emerg. Tank	3,3000				
	Loss to Chill Lines	2,000				
	Conversion to GH ₂	<u>5,295</u>				
	TOTAL	64,995		124,700	22.5 hr = 1-1/2 days	Recharge Based on 300 gal. transfer loss per 7,800 gal. trailer and 1-1/2 hr unloading time/trailer.
Liquid Nitrogen	Normal Cooldown	8,750	200 psia at 200°R			
	Conversion to GN ₂	<u>69,900</u>				
	Use Factor 1.5 X	<u>78,650</u>				
	TOTAL	117,975		189,000	4.5 hours	Recharge based on 300 gal. transfer loss per 7,800 gal. trailer and 1-1/2 hr unloading time/trailer.
Liquid Oxygen	Steam Generator System	46,000	350 psia at 160°R	175,000		Based on 1020 sec at operation +20% contingency
Propane	Steam Generator System	13,000	250 psia at amb.			Based on 1020 sec of operation +20% contingency.
	Flare Stack Pilot	<u>1,150</u>				Based on 5 hr of operation.
	TOTAL	14,150		81,000		
Process Water	Duct Coolant, Stand Deluge, Shields, etc.	4,600,000				
	Steam Generator System	110,000	200 psia at amb.			Based on 1020 sec. operation + 20% contingency
	Steam Generator System Cooling	<u>1,125,000</u>	200 psia at amb.			
	TOTAL	5,835,000		20,800,000	4.00 days (pump)	Recharge based on pump capacity of 146 gpm. Recharge based on demineralizer capacity of 167,000 gpd.
Gas Hydrogen	Run Tank Pressure	735	50 psig at amb.			
	Storage Tank Pressure	1,285	60 psig at amb.			
	Engine Act. Supply	360	220 psig -			
	Normal Cooldown	1,500	500 to 250 psia at amb.			Useful available based on bottle terminal press. at 500 psig. Three high pressure vessels available.
	Emerg. Cooldown Tank Press.	<u>160</u>	350 psig at amb.			
	TOTAL	4,040		4,545	168 hr = 7 days	Recharge based on available 100 scfm pump capacity and recharging total required. Recharge capacity must be double to meet that schedule requirement.
Gas Nitrogen	Normal Cooldown (200°R)	8,750	200 psia at 200°R			
	Normal Cooldown (amb.)	4,500	25 psia at amb.			
	Shield Seals	1,800				
	LN ₂ Tank Pressure	7,030	250 psig at amb.			
	Flare Purge	470	10 psig at amb.			Useful available based on bottle terminal pressure of 450 psig. Two HP vessels available. Additional capacity required.
	Engine Compartment Inerting	12,000	30 psig at amb.			
	Steam Gen. Sys. Propellant Pressurization	6,970	400 psig at amb.			
	Steam Gen. Sys. Purge	<u>10,000</u>	100 psig at amb.			
	TOTAL	51,510		44,200	196.5 hr = 8.2 days 48.6 hr = 2.00 days	Recharge based on 100 scfm pump capacity and recharging total required. Recharge based on recommended vaporizer unit.
GAS Helium	Fac. Act. Control *	1,000	550 psig at amb.			
	Emerg. Engine Cooldown	4,500	1000 to 500 psia at amb.			
	Purge Run Tank	250	50 psig at amb.			Useful available based on bottle terminal pressure of 600 psig. One HP vessel available. Additional capacity required.
	Purge Lines & Eng.	<u>220</u>	50 psig at amb.			
	TOTAL	4,970		3,040	80.0 = 3.33 days	Recharge based on 100 scfm pump capacity and recharge of total required

* Not included in total requirement of terminal pressure definition - supplied by other sources.

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