ATOMICS INTERNATIONAL
A Division of North American Aviation, Inc.

MASTER

NAA-SR-MEMO-2071

Do not remove
this sheet

This document contains 5 pages

This is copy _____ of _____ series _____

UNCLASSIFIED

Security Classification

*NAA-SR-MEMOs are working papers and may be expanded,
modified, or withdrawn at any time,
and are intended for internal use only.*

This report may not be published without the approval of the Patent Branch, AEC.

released 11/21/60

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to, any information pursuant to his employment or contract with the Commission.

682 001

715E

WRITTEN BY C. W. Griffin		ATOMICS INTERNATIONAL A Division of North American Aviation, Inc. TECHNICAL DATA RECORD	TOR NO.
SECTION Reactor Development			2071
GROUP Sodium Graphite Reactors			GO 9693
UNIT			LEDGER ACCT.
APPROVED BY: <i>[Signature]</i> (SUPERVISOR) D. H. Johnson		PROGRAM SRE	SUB-ACCT. 4197
OTHER		PROJECT	TWR
		Engineering Improvements in the SRE	DATE 19 August 1957
			PAGE 1 OF 5

TO: D. H. Johnson

COPIES TO:

P. R. Augustine	E. D. Falk	M. W. Hulin
J. R. Churchill	F. E. Faris	K. K. Kennedy
G. E. Deegan	W. J. Freese	J. E. Owens
R. E. Durand	L. E. Glasgow	L. Silverman
R. L. Eichelberger	R. B. Hinze	Engineering Files (7)

SUBJECT: An Investigation of the Feasibility of Replacing Helium with Nitrogen as a Cover Gas in Certain Specified Areas as an Economy Measure.

CONTENTS:

I	STATEMENT OF PROBLEM	PAGE 1
II	SUMMARY OF RESULTS AND RECOMMENDATIONS	PAGE 1
III	METHOD USED, DESCRIPTION OF EQUIPMENT, SAMPLE CALCULATIONS . . .	PAGE 2
IV	REFERENCES AND APPENDICES	PAGE 5

I STATEMENT OF PROBLEM

Our present cost of helium is about twenty-three dollars per 250 SCF and commercial nitrogen about two and one half dollars per 250 SCF. With the installation of a proposed cascade system for use of liquid nitrogen from the Lox plant, the cost of nitrogen will become about fifty cents per 250 SCF.

Our present helium cost for one week of operation ranges from eight hundred to one thousand dollars during normal operation, depending on how much is used to clear lines, etc.

Presented herein is a summary of information obtained through personal interviews and technical papers on the potential use of nitrogen in some of the areas where we are not using helium.

II SUMMARY OF RESULTS AND RECOMMENDATIONS

Because of the high affinity of zirconium for nitrogen, it is not felt desirable at this time to consider the use of nitrogen as a cover gas in the primary sodium system. Tests now in progress may indicate, however, that we should take another look at this area with respect to the use of nitrogen.

Due to the high pressure maintained in the control and safety rods, it is not now advisable to use nitrogen in these areas since in the event of a thimble rupture, nitrogen would enter the primary system. It is, however, recommended that the pressure in the control rods be reduced to one psig over that of the core rather than the 15 psig used on the safety rods since no snubber action is required.

662 002

TECHNICAL DATA RECORD

PROGRAM SRE

Engineering Improvements
PROJECT in the SRE

TOR NO. 2071
DATE 19 August 1957
PAGE 2 OF 5

With the inclusion of a Nak Bubbler and a drier, nitrogen can be used in the secondary system since nitriding of stainless steel is negligible and it is virtually impossible to form sodium-nitrogen compound in our system. This change is recommended:

There is apparently no reason for not changing to nitrogen in the core cavity liner and there are advantages to be gained such as the ability to detect a bellows leak and the reduction of diffusion of inert gas to the high bay area.

III DISCUSSION AND SAMPLE CALCULATIONS

This investigation was conducted with respect to three main areas; which were the primary sodium system, the secondary sodium system, and the core cavity liner. The fuel storage and coffin area were not included for analysis at this time. All of these areas are at present using helium as a cover gas.

Due to the large amount of zirconium in the primary system and the known tendency of zirconium to react with nitrogen, hydrogen, and oxygen, it is felt that at this time no move should be made to replace helium with nitrogen in this system. However, R. Eichelberger is conducting tests on zirconium and other material in sodium under a nitrogen blanket at present in a loop at the ETB. The results of these tests will not be available for several months but may warrant further investigation with respect to this system.

The control and safety rods are tied into the primary system since a ruptured thimble at 15 psig would flood the core with nitrogen. This 15 psig was recommended as operating pressure by ETB for its excellent snubbing action. Tests are now in progress at the ETB to determine the snubbing action at various pressures and a high strength zirc-alloy thimble is being proposed for future use. These tests and changes may make it possible to use nitrogen at some later date. Since there is no snubbing action required in the control rod thimbles, it is recommended that the helium pressure be reduced to 1 psig above the core pressure.

The secondary sodium system, however, looks much more promising. The three main points of possible objection to nitrogen as a blanket for sodium in this system are:

1. Chemical activity with sodium
2. Nitriding of stainless steel
3. Oxygen and water in the nitrogen

In discussion 1 and 3 with L. Silverman of the chemistry department, I was informed that the formation of sodium and nitrogen compound is very difficult under the most favorable conditions and that under our condition of operation it would be virtually impossible to have any such reactions. Any excessive oxygen or water content would be taken care of by the incorporation of a drying agent and a Nak bubbler in the system.

TECHNICAL DATA RECORD

PROGRAM SRE

Engineering Improvements
PROJECT in the SRE

With respect to 2, R. Eichelberger informed me that, whereas very few extensive investigations have been made to determine the degree of nitriding to be expected with nitrogen and sodium in stainless steel, all available information indicates that the degree of nitriding would be negligible. He is at present conducting some tests in his loop but could not honestly feel that any additional information which he might obtain with respect to stainless steel would be of such value as to warrant holding up a proposed change.

A brief summary of two technical reports by Mine Safety Appliance Company is included as follows:

(1) Technical Report 53, Mine Safety Appliance Company, Callery, Pennsylvania
A STUDY OF NITROGEN AS A COVER GAS IN SODIUM SYSTEMS

Nitrogen used as a cover gas in several MSA sodium systems, ranging from 900 to 1100°F and 1 to 7 ft/s at 10 psig did not induce excessive corrosion of type 304 and 347 stainless steel and tool specimens. Average corrosion rates found of the stainless steels ranged from +0.01 to +0.23 mg/am²mo, and tool steel ranged from -0.24 to -0.96 mg/am²mo.

One per cent by weight of calcium added to the loop during two tests showed calcium reduced to a trace in overnight cold trapping at below 300°F.

It is the opinion of the authors that the tool steel and type 304 and 347 stainless steels are not subject to gross nitriding under the conditions described.

(2) A similar run was made and described in Technical Report 49 for a cover gas of nitrogen containing two per cent volume of oxygen. Nitriding was general throughout the entire loop.

Note: The calcium tests are important since calcium acts as a transport agent for oxygen or nitrogen to any zirconium or stainless steel even though there would be very little nitrogen entrained in the system in solution. The compounds do not cold trap readily.

Mr. Markem, the technical representative of Dupont for this area, states that all processing concerns who produce sodium use nitrogen as a cover blanket throughout the entire production process.

Since there is no zirconium in the secondary system, the basic objection to use of nitrogen in the primary system does not hold.

There would therefore appear to be no valid reason for not using nitrogen in place of helium in this system.

To determine why helium had been designated as the inert gas in the core cavity lines, J. Churchill, 795-52, was contacted. It was brought out that originally we wished to detect the leak-proofness of the core cavity lines and the interface between the cavity and the core. If there had been a leak between the core and the core cavity line, the design feature was such that

the cavity level would be kept at a higher pressure than the core. Thus helium would leak into the core and nitrogen could not be used.

Subsequent tests of the actual operation has shown that there is no leak between the core cavity and the core cavity lever. (W. J. Freede to D. H. Johnson, 2 April 1957) But the cavity line leaks into the high bay area such as to prevent operation at the design pressure. Therefore, since these two reasons are no longer valid, nitrogen could be considered. However, due to the leakage of the inert gas into the high bay area it was requested by one of the shift supervisors that an analysis of the potential hazard due to carbon-14 from irradiated nitrogen be made. This analysis by M. Hulin, 791-22, is:

In calculating the carbon-14 activity from the irradiation of nitrogen in the thermal shield cavity, the following assumptions were made:

- Inside diameter of outer tank = 12.5 feet
- Outside diameter of core tank = 11.25 feet
- Outside diameter of thermal rings = 12.4 feet
- Inside diameter of thermal rings = 11.5 feet

Data from report NAA-SR-1517 were used to obtain the following reactor parameters:

- Total macroscopic cross section of stainless steel $\Sigma_s = 0.646 \text{ Cm}^{-1}$
- Total macroscopic cross section of sodium $\Sigma_{NA} = .895 \text{ Cm}^{-1}$
- The reactor radius, $R_{c1} = 158.31 \text{ Cm.}$
- The reactor core radius for a 43 element fuel loading, $c = 96.7 \text{ Cm.}$ $\frac{R_c}{c} = 1.635$

Using this factor we obtain from report NAA-SR-1517 the average normalized thermal neutron flux as one tenth the average center line fast neutron flux.

If we assume the average fast neutron flux at a power level of 20 megawatts is $1.5 \times 10^{12} \text{ nv}$, then the average thermal neutron flux at the outer edge of the reflector is $1.5 \times 10^{11} \text{ nv}$. We next consider the extenuation of the thermal flux in passing through 2.5 inches of sodium and 1.75 inches of stainless steel. If we consider the reflector as an infinite slab source of neutrons, we can use the following relationship:

$$\phi_1 = \frac{\phi_0}{2} e^{-\sum_i (\xi_i X_i)}$$

$$\text{where } \sum_i (\xi_i X_i) = \sum_{ss} X_{ss} + \sum_{NA} X_{NA} = 8.55$$

$$\phi_1 = 1.5 \times 10^{11} e^{-8.55} = 1.45 \times 10^7 \text{ nv}$$

for the reaction $^{14}\text{N} (n, p) ^{14}\text{C}$ $\sigma_a = 1.75 \text{ barns}$

At a power level of 20 Mw the temperature in the thermal ring cavity is expected to be approximately 700°F. Using the formula $\rho = \frac{1}{v} = \frac{P}{RT}$ where

$$P = 16 \text{ psi}$$

$$R = \frac{1545}{M} = \frac{1545}{28}$$

M = molecular weight of nitrogen

$$T = 460 + 200 = 1160^\circ \text{ R}$$

$$\rho = .036 \text{ lb/ft}^3 = .000577 \text{ g/cc}$$

from which we obtain $\Sigma_N = 4.35 \times 10^{-5} \text{ cm}^{-1}$

If we take the thickness of the nitrogen layer as .35 inches, then the activation flux is $\phi_2 = \frac{\phi_1}{2} (1 - e^{-\Sigma_N x}) = 280 \text{ nv}$

The activity of carbon-14 after ten years is $\lambda A = \Sigma_N \phi_2 (1 - e^{-\lambda T})$
 $\lambda = \frac{.693}{5800}$

$$\lambda A = .0004 \text{ } \mu\text{curies}$$

This is an extremely small quantity.

Conclusion

With the size of gas leaks anticipated, the amount of radioactive carbon emitted to the atmosphere should be extremely small.

If a leak should develop in the bellows, which is the most likely area, we should wish to know it at once. And since the core cavity liner is now, of necessity, kept at a lower pressure than the core, the use of nitrogen would make it very easy to make such a detection since any helium in the liner would have to come from the core.

It is therefore concluded that nitrogen could be used in this area.

In general, all other things being equal, nitrogen has the added advantage of approximating the density of air and thus has less tendency to leak or defuse even where a crack or hole exists.

IV REFERENCES AND APPENDICES

1. Technical report 53, Mine Safety Appliance Company, Gallery, Pennsylvania
2. Technical report 49, ibid.
3. W. J. Freede to D. H. Johnson, 2 April 1957