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JOINT OPERATION OF THE TSTA UNDER THE COLLABORATION BETWEEN JAERI AND U.S.-DOE

—TSTA EXTENDED LOOP OPERATION WITH 100 GRAMS OF TRITIUM ON APR.-MAY 1992—

March 1993

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Joint Operation of the TSTA under the Collaboration between JAERI and U.S.-DOE - TSTA Extended Loop Operation with 100 grams of Tritium on Apr. - May 1992 -

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An extended loop operation of the TSTA with the J-FCU was performed successfully with 100 grams of tritium on April-May 1992. One of the major purposes of this extended loop operation was to demonstrate stable control and safe operation of the entire TSTA during 25 days. This is one of the major milestones of the Collaborative Program on technology for fusion-fuel processing under the Annex IV between JAERI and US-DOE.

From a technical point of view, this extended loop operation produced many highlights. Specially, it was noteworthy that the ISS with full four columns was controlled stably for 22 days. It was also noteworthy that the TSTA-FCU with magnesium bed and the J-FCU were first operated under the complete integrated TSTA loop with full (4) columns

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ISS and that both FCUs were processed simulated fusion-fuel exhaust with a various range of impurities stably and safely.

This report describes the entire test plan and the brief test results.

Keywords : Fusion, Fusion Fuel Cycle, Tritium, Fuel Cleanup, Isotope Separation, TSTA, Cryogenic Distillation, Magnesium Beds, Palladium Diffuser, Ceramic Electrolysis Cell, J-FCU

日米協力 Annex Ⅳに基づくTSTA共同試験
－100gのトリチウムを用いたTSTAループの
25日間連続運転試験の概要（1992年4－5月）－

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（1993年3月8日受理）

原研は日米核融合研究協力協定Annex Ⅳに基づき，米国ロスアラモス国立研究所のトリチウムシステム試験施設（TSTA）において核融合炉燃料ループの実証試験を行っている。本試験は，TSTAループ全体の長期間安全定常運転の実証を最大の目的として，1992年4－5月に行われたものであり，Annex Ⅳ最大のマイルストーンであった。

試験は25日におよぶ昼夜連続運転であったが，ISS（深冷蒸留水素同位体分離装置），FCU（燃料精製捕集装置），J－FCU（JAERI－燃料精製捕集装置）等すべてのサブシステムが安定に制御された。また，マグネシウムベッドを用いたFCUおよびJ－FCUは，はじめての全てのTSTAループとの連結運転であったが，多岐にわたる不純物を含む模擬プラズマ排ガスを安全かつ安定に連続処理することを実証した。

本報告書は，上記試験における詳細試験計画と試験結果の概要をまとめたものである。

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1. Introduction

In June 1987, the Japan Atomic Energy Research Institute (JAERI) and the United State Department of Energy (DOE) signed a collaborative agreement (originally 5 years), Annex IV to the Japan/U.S. Agreement on Fusion Energy, regarding development of technology for fusion-fuel processing. Under this agreement, JAERI and DOE have continued joint operations and experiments on fusion-fuel processing technology with the Tritium Systems Test Assembry (TSTA) at the Los Alamos National Laboratory (LANL)[1-2].

The TSTA [3] is a simulated fusion fuel loop that mainly consists of a torus mockup system with cryopumps (VAC), Fuel Cleanup System (FCU), Isotope Separation System (ISS), Transfer Pump Systems (TP1, TP3), Uranium Tritide Storage and supply System (UTB), and Tritium Load-in/load-out System (LIO). The TSTA has also safety systems such as Tritium Waste Treatment System (TWT), Secondary Containment System (SEC), Tritium Monitoring System (TM), Master Data Acquisition and Control System (MDAC), and Building Ventilation System (VEN).

The Annex IV collaboration was mainly divived two periods. One was the earlier 2.5 years with the original TSTA subsystems and/or loop operations and experiments. The other was the later 2.5 years including a JAERI Fuel Cleanup System (J-FCU) operations and experiments in the TSTA loop.

The J-FCU was designed, fabricated, and installed at the TSTA as a subsystem for the TSTA loop comparing the TSTA-FCU [4-6]. Generally, Fuel Cleanup System has mainly two functions that are purification of hydrogen isotopes and recovery tritium from impurities. For the purification, TSTA FCU uses cryogenic molecular sieve beds and J-FCU uses a palladium diffuser. For the tritium recovery, TSTA-FCU selects catalytic reactor - cold trap - hot metal bed chain and the J-FCU selects a catlytic reactor - cold trap - ceramic electrolysis cell chain.

During past 5 years of the Annex IV, many subsystems and loop operation and tests were performed and a lot of progress were obtained. J-FCU has been in tritium test since March,'91[7-8]. Finally, at the end of the original five year collaboration of Annex IV (April-May, '92), a extended TSTA loop operation (about 25 days) was performed successfully in order to demonstrate stable control and safe operation of the entire TSTA with the J-FCU.

The present report describes the detail test plan of this 25 days extended loop run of the TSTA with the J-FCU and the brief test results. The detail test result of J-FCU will be summarized in the other report [9].

2. Test Plan

2.1 General Test Plan

2.1.1 PURPOSE

The main purposes of this run are:

(1) Extended operation of the integrated TSTA fuel processing loop. The run will last up to, but not more than, 25 days. The projected start date for this run is April 20, 1992. If the run starts on that date, the run will terminate by May 14, 1992. In this case, May 15 will be devoted to post-run cleanup and processing.

(2) Operate the ISS in 4-column configuration, using the Raman system for chemical analysis of FCU and ISS operations. Operation of the ISS is described in Attachment 2 to this Test Plan

(3) Operate the TSTA FCU with Mg beds during loop operations. Demonstrate the complete FCU cycle including MSB loading/regeneration and DTOF loading/regeneration during a loop experiment. Operation of the FCU is described in Attachment 3 to this Test Plan

(4) Operate the JFCU, with impurities, in TSTA loop operation. Demonstrate the interface/integration of the JFCU with the TSTA loop. Operation of the JFCU is described in Attachment 4 to this Test Plan

(5) Cleanup TSTA PCs that contain mixtures of hydrogen isotopes and impurities. Purify and separate the tritium contained in these PCs.

(6) Provide operator training and qualification of TSTA Facility Operators on TSTA subsystems.

(7) If time permits, and if all installation work is completed on the JVAC, operate JVAC, for a short period, with tritium, during the last week of this test. Operation of the JVAC is described in Attachment 5 to this Test Plan

2.1.2 CONFIGURATION

The TSTA flow loop will be configured during start up as shown in Figure #1. During the first week of this test, the TSTA FCU will be included in the integrated loop. During the second week, the JFCU will be included in the integrated loop. During weeks three and four, the loop configuration will include FCU and/or JFCU, whichever provides the most stable operation. During weeks three and four, there will be minimal impurity injection. During these weeks the main objective is continuous, stable operation. The configuration will be selected at a TSTA huddle at the beginning of week three. The configuration selected at that time shall be documented on a TSTA Work Instruction.

Specific configurations of the TSTA flow loop during operation with FCU and JFCU operations are defined in Attachments 3 and 4. If testing with the JVAC is achieved during this test, the specific configuration for these tests is defined in Attachment 5.

The TSTA cell will be configured to maintain the proper pressure differential. This requires that all doors and air lock procedures be followed.

2.1.3 SUBSYSTEMS REQUIRED

The following systems will be used:

ISS-	Columns I, H, D, and T
FCU-	Complete system, including Mg beds
JFCU-	Complete system
TPU-	TP3 for prime mover of DT process gas
TP1-	For maintenance as needed or to proved a path as needed
JVAC	Normal operation as defined in Attachment 5
IMS-	Impurity injection as defined in Attachments 3 and 4
UTB-	All beds as needed
GAN-	ISS RAMAN & GC sampling
RAMAN-	Analyses as needed
TM-	Normal operation
PEV-	Process evacuation
H/VAC-	Maintenance as needed
MDAC-	Normal operations
TWT-	Normal operations
UTIL-	Normal operations
LIO-	Empty PC's will be attached for safety and to unload pure T_2

2.1.4 PERSONNEL

TSTA management will be the Test Directors (TD) and are responsible for the safe operation of this facility. All necessary TSTA personnel will be distributed into one of three shifts. Shift assignments are listed in Attachment 1. The minimum required personnel for any shift are two facility operators and one JAERI staff member assigned by TSTA management. Shifts A and B are working shifts, and as such will have additional TSTA staff members on-site at all times. Shift C will be a "holding" shift. During the weekdays the "C" shift will have two facility operators and a JAERI staff member on-site at all times.

During periods of operation of the JFCU, a qualified JFCU Operator shall be on-site at all times. During periods of JFCU operation a JFCU-qualified JAERI staff member shall be on-site at all times.

During this extended loop run the TSTA facility must be staffed 24 hours per day, 7 days per week. All Facility Operators, TSTA staff members and JAERI staff members will be assigned shift responsibilities. No person will work more than 12 days without at least 2 days off. The off days will occur on the weekends. The schedule for weekends will be established by the Test Directors, documented on a TSTA Work Instruction, and communicated to the staff at Shift Change Meetings, no later than Thursday of each week. During the weekends, a minimum of two Facility Operators, or one Facility Operator and one TSTA staff member shall be on-site at all times. All other staff members, and all JAERI staff members shall be available for emergency calls during the weekends. Any plans for these staff members to be out of Los Alamos during this period must be cleared with the Test Directors before leaving town.

A loop operator (LO) is specified during a run. This person will be one of the Facility Operators. The TD can appoint an alternate facility operator to replace the LO.

The LO's responsibilities include:

- the coordination of loop operations with other TSTA systems. The LO will work directly for the TD to handle the operations from the Control Room (CR) Man Machine Interface (MMI). Most MMI commands which will change the systems parameters will be executed by the LO or a trainee under LO supervision.

- keeping the TD informed of all operations within the facility. All personnel within the facility are responsible for keeping the LO informed.

Shift change meetings will be held at 0730, 1530, and 2330. All TSTA members should attend shift change meetings during their working day. The departing loop operator will conduct the shift change meeting. The arriving LO will record all new information exchanged at the shift change meeting in the control room notebook. The shift changes will proceed in accordance with TTA-OP-100-06.

The responsibilities for personnel during normal operations are listed in Attachment 1, Table I.

During an "Emergency" (determined by the TD or the LO), personnel will be assigned to their system as listed in Attachment 1, Table I.

Under emergency conditions, the ability exists to isolate components and immediately dump the process gas to the UTB's. This will control gas pressures and flows, and maintain safe operating conditions. The emergency actions are initiated either manually or automatically. SCRAM macros (safety shutdowns) are programmed into the computer system for the TPU, ISS, LIO FCU, JFCU and PEV systems. These are predetermined sequences of operations which will shutdown a particular process and restore safe conditions. Safety programs are resident in the computer software which automatically sense critical process variables and make calls to the appropriate SCRAM macros when necessary. For the TPU system, a metal bellows pump discharge pressure in excess of 2000 torr will shutdown the pumps and isolate the system. The Macro for the ISS will open the ISS to the UTB and decrease pressure when a column pressure of 2000 torr is reached. The ISS and UTB Safety Programs must be in operation when UTB's are being off-loaded to the ISS.

The TSTA process loop has been designed to "fail-safe", that is, under a complete loss of electrical power all process valves will fail in the safe position, thus avoiding a loss of tritium to the secondary containment, and/or the environment. This failure mode has been tested.

2.1.5 SCHEDULE

The run is expected to start on April 20, 1992 at 0730 and end on May 14 at 1630. The facility will be staffed continuously through the run.

Operations involving the process system will begin with the "A" shift on April 20, 1992. This shift will start up the ISS refrigerator and have ISS columns I, H, D, and T cooled down to approximately 23K. They will also prepare the UTB system and turn on the heaters for the U-beds that will be off-loaded first.

The FCU will be activated as described in Attachment 3 of this Test Plan.

The Raman system may be started on April 20.

The following operations will be completed before the run begins.

- All glove boxes will be leak checked before use. (Procedure TTA-TP-117-07) All process lines, that have been opened since the last tritium testing, will be leak checked with low level tritium gas before these lines are placed in loop operation.
- TTA-OP-100-03, "LOOP OPERATION CHECKLIST" will be completed.
- The TWT GC which will separate neon peaks from hydrogen isotope peaks, will be verified to be operational.
- Purge ISS GC lines.
- Complete ISS pre-run preparation as described in Attachment # 2.
- Complete FCU pre-run preparations as described in Attachment #3.
- The Raman will be tested with samples from ISS. Hydrogen isotopes (D_2) available from a cylinderwill be used for identification and calibration. ISS and sample lines will be filled with ^4He, not D_2, before the run is started.

- The IMS will be activated. The nominal impurity mixture to be added during this test is a 10% methane in nitrogen mixture that will be added at 1% of the loop flow rate.

- A number of PCs, selected from the NM (Nuclear Materials) tritium inventory for account 230, will be emptied during the week of April 13. The gas in these PCs, to be purified during this run, will be transferred from the PCs into the UTB standard volume. The number of PCs to be so emptied will be determined by the ISS, FCU, and UTB designers. The total volume of gas transferred from PCs into the standard volume will be such that the pressure in the standard volume is less than 580 Torr. The list of available PCs in given in Attachment 6 and the PCs to be emptied into the standard volume during the week of April 13, is given in Attachment 7 to this Test Plan. If other PCs are to be emptied into the loop during the course of this Test, the specific PCs will be identified on a Work Instruction.

- One empty PC will be attached to the LIO during this test. The exception to this requirement, is during periods, if any, when a PC is being emptied into the loop.

- If process loop cumulative tritium release to TWT reaches (or is about to reach) 500 Ci (or a multiple thereof), a huddle will be called by the Test Director to assess the source, rate, and projected total amount and plan appropriate remedial actions (if any).

2.1.6 POSSIBLE HAZARDS

Large quantities (approximately 100-130 grams) of tritium will be handled during this run. If accidentally released, it could pose a health hazard to personnel. All operations that will be performed during the run are covered by procedures approved through the TSTA QA system. To mitigate the effects of accidents, all safety systems are required to be operational.

2.1.7 OUTLINE

DAY 1

0730 "A" shift:

- Prepare and turn on heaters to UTB's #2 and #4, and set the controllers to 450^{o}C. (MMI Safety to 500 ^{o}C)

- When the pressure in the UTB's are slightly greater than the ISS column pressure, open the evacuation valves to the ISS.

- Start the ISS refrigerator and cool columns I, H, D, and T to approximately 24k.

Continue operations at ISS per Attachment 2.

- Perform FCU operations per Attachment 3.

- Run pure D_2 sample for Raman spectrometer calibration.

1530 Shift "B" will:

- relieve shift "A" after the shift change meeting in the support center.

- continue ISS operations per Attachment 2

- continue FCU operations per Attachment 3

- continue unloading the UTB's until empty as determined by closing the ISS isolation valves and monitoring the pressure increase over the top of the UTB's.

- set the controllers for UTB #2 & #4 to 0°C, and set the controllers for UTB #1 and #3 to 450°C. (MMI safety 500 °C)

- when pressure in UTBs #1 and #3 reaches the pressure in the ISS columns, begin condensing gas into the ISS.

- when UTBs #1 and #3 are unloaded, reset the MMI and the controllers to 0°C.

This operation will take longer then one shift. Shift "C" will relieve shift "B" at 2330 and continue unloading of the UTB's

DAYS 2-5

LOOP OPERATIONS

As soon as the gas from the UTB's has been loaded into the ISS and the loop shows no signs of tritium leakage, loop flow through the ISS/TP3/FCU can be initiated. Operations, in general, will be as detailed in "Working With Tritium" TTA-SOP-100-3.

FCU OPERATIONS

The FCU operations will proceed as defined in Section 8 of Attachment 3.

ISS OPERATIONS

ISS operations will continue as defined in Section 8 of Attachment 2.

EMERGENCY SHUTDOWN OF THE ISS

If it should become necessary to perform an emergency shutdown of the ISS the uptake of hydrogen isotopes by the uranium beds will become diffusion limited due to the buildup of ^3He. This condition can be alleviated by circulation through the U-bed affected and TP1.

If plugging of the ISS feed lines occurs, proceed as follows.

- First determine the location of the plug.
- If it is determined that the plug can not be cleared, dump the contents of the ISS to the TB's.
- Warm ISS as necessary to clear the plug.
- Cool the ISS, reload Q_2 from the UTB's; and restart ISS, TPU, and IMS operations.

RAMAN

The Raman system will be operated as specified above under ISS OPERATIONS and also in test plan TTA-TP-124-04, R0.

DAYS 6 and 7

During the weekend of April 25-26, the TSTA loop will continue with flow through FCU MSB1 with no impurity addition to the loop.

DAY 7

Start JFCU component heating/cooling.

DAYS 8-12

Operation of the TSTA loop with JFCU. ISS operation will continue with 4-column operation, Raman analysis of column profiles will continue as defined in Attachment 2.

JFCU operation will be initiated as described in Attachment 4 to this Test Plan.

DAYS 13-14

During the weekend of May 2 and 3 the TSTA loop will continue to operate with flow through the JFCU bypass lines or FCU, but with no impurity addition. During this period the JFCU components will be kept at operational temperatures.

DAYS 15-23

On day 15 (Monday May 4) flow will be shifted or started through through the FCU. No impurities will be added from IMS. Stable operation of the TSTA loop, with FCU and ISS in operation will continue. Analysis of the ISS columns using the Raman system will continue.

During the third and fourth weeks of this experiment the reference TSTA loop will include the FCU. A decision to include JFCU rather than FCU could be made after extensive discussion with the entire staff. Such a decision would be based on the following two points:

- the one week operation with the JFCU was not sufficient to complete all of the required testing of JFCU, and
- the JFCU operation during week two demonstrated that operation of the JFCU was less complicated and labor intensive than experienced during previous JFCU operations.

Such a decision to operate with JFCU during weeks three and four would be documented on a TSTA Work Instruction.

Once stable operation is achieved (with the selected FCU/JFCU) a TSTA huddle will be convened. At that time, a decision will be made regarding the possibility of emptying other PCs into the loop. Any decision to do so will be documented using a Work Instruction. This Work Instruction will include the specific PCs to be emptied and the sequence in which the PCs will be attached to LIO and emptied into the Loop. The emptying of these PCs into the loop is a desirable objective of this test, but is not a requirement. PC's to be used for this phase of the run are itemized in Attachment 7.

If the JVAC installation and safety analysis is completed by May 11, a decision to proceed with tritium testing of JVAC may be made at a TSTA Huddle of Shift Change Meeting. This decision shall be documented on a TSTA Work Instruction, and communicated to all personnel. The operation of JVAC during the extended run is defined in Attachment 5 of this Test Plan.

DAY 23

If PC's have been loaded onto MSB1, N_2 or Ar must be added to fully load MAB1 with impurities (see Attachment 3).

Shutdown of the process loop will be in accordance with TTA-SOP-108. Shutdown of loop operations will commence with the A shift on May 14.

Once it is established that UTB's are safely accepting the gas evolved from the ISS, proceed to unload gas from the FCU as defined on page 5 of Attachment 3 to this Test Plan. Circulate gas through the system (TPU-FCU-ISS) over the UTB's to remove the remaining hydrogen isotopes. This operation can be concluded after FCU molecular sieve beds are at 400 K. The FCU should then be evacuated and the MSBs isolated. HTO must be prevented from entering the UTB's.

DAY 24

Finish regeneration of FCU's and loop cleanup.

2.1.8 DATA REQUIREMENTS

All TSTA data channels, beginning with the cool down of the ISS, will be stored on a tape after the run by the software personnel.

Relevant subsystem data will be recorded in the appropriate logbooks.

Tritium added or removed from the LIO system will be recorded by the LIO operator in the LIO notebook and by the LO at the MMI. The NM custodian will record this transfer in the inventory records. The TD will ensure that accounting data is logged. Operating Procedure TTA-OP-125-01 will be followed.

A complete inventory of all PC's used in the run and all UTB's will be completed after the run and before this test plan can be closed out.

Shift change minutes will be recorded in the control room log book. The Shift Change Checklist from Operating Procedure TTA-OP-100-06 will be filled out by the Facility Operators at each shift change.

Records will be kept according to Records Control Procedure TTA-QP-10, R2.

2.1.9 CALIBRATIONS

Calibration requirements for items of equipment, data channels, etc. are covered in the appropriate attachments to this test plan.

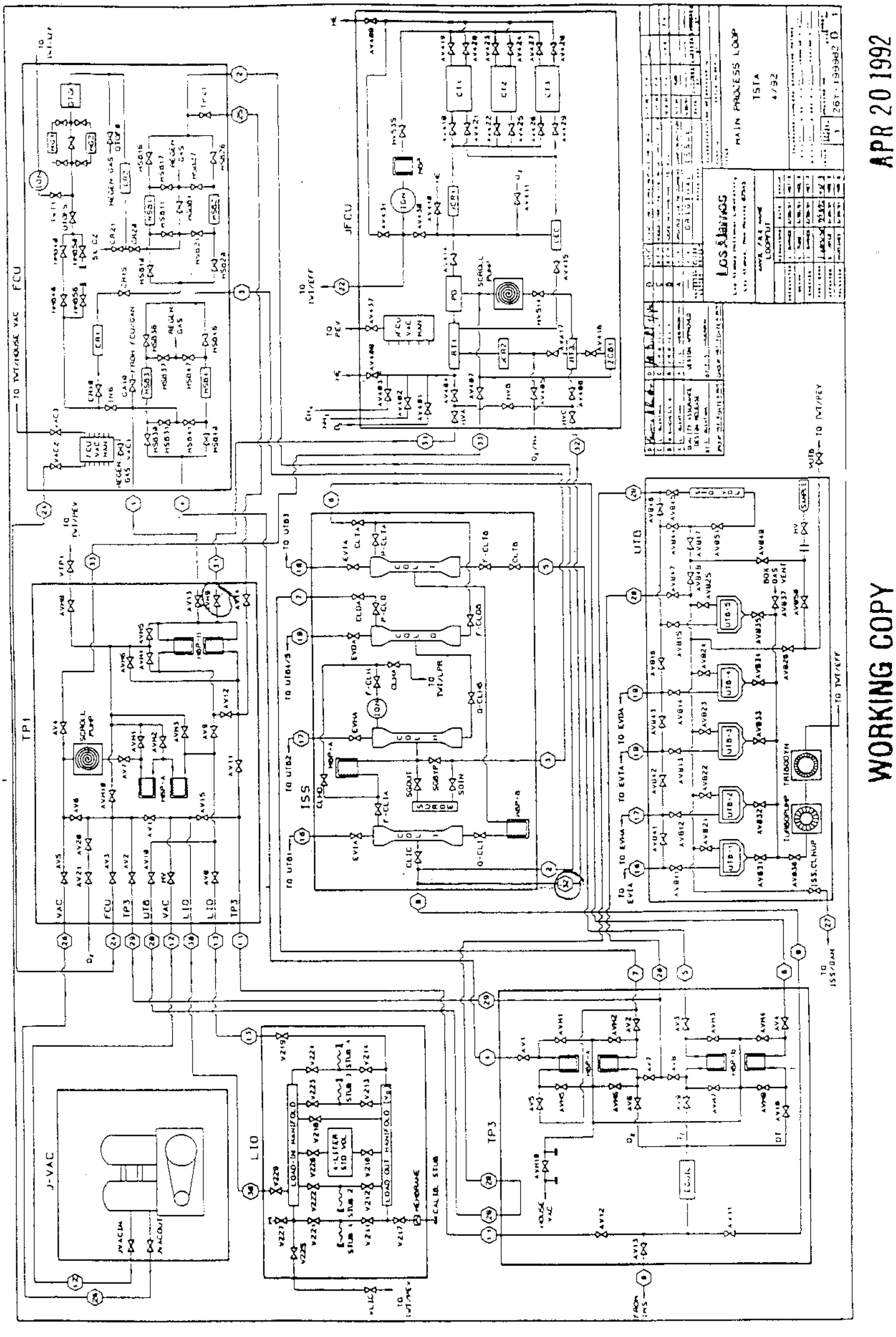

Fig.1 Loop Configuration for Extended Run

2.2 Attachments

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Attachment 1

ATTACHMENT 1

2.2.1 Shift Assignments for the TSTA extended run
April 20-May 15, 1992
92-3

TABLE I SHIFT ASSIGNMENTS

	Shift A 0730-1530	Shift B 1530-2330	Shift C 2330-0730
Test Dir	Bartlit	Anderson	Loop Operator
Alt TD	Carlson	Willms	
Loop Operator	Jenkins	King	Wilhelm
JFCU Operator	Harbin [Jenkins]	King [Dahlin]	Wilhelm [Hamerdinger]
Facility op.	Harbin	Dahlin	Hamerdinger

TSTA Subsystem	Shift A 0730-1530	Shift B 1530-2330	Shift C 2330-0730
ISS	Sherman JAERI	Barnes JAERI	JAERI
FCU	Carlson/JAERI	Willms/JAERI	
UTB	Nasise	(Nasise)	
TPU	Jenkins	King	
LIO	Nasise	(Nasise)	
TWT	Nasise	(Nasise)	
ETC	Harbin	King	Wilhelm
IMS	Nasise	Willms	
ISS-GC	Sherman JAERI	King JAERI	Wilhelm JAERI
MDAC	Cole	(Cole)	
GAN-RAMAN	Sherman/Taylor/ Nakamura *	JAERI **	
JFCU	JAERI	JAERI/Barnes	JAERI
JVAC	Nakamura/Nasise	Operator/Dahlin	(Dahlin)

NOTES:

1. All others will be on the A Shift and subject to call as needed.

2. Some personnel on Shifts A & B may shift hours between shifts (with the cognizance of the TD) depending on specific activities under way.
3. Personnel in (...) are on call. Personnel in [...] are in training.

TABLE II SHIFT ASSIGNMENTS (Addendum)

	Shift A 0730-1530	Shift B 1530-2330	Shift C 2330-0730
1st week (Mon-Fri)	Inoue Hayashi	Hirata	Nakamura
2nd week (Sun-Fri)	Hayashi Hirata	Konishi* Nakamura	Inoue
3rd week (Mon-Fri)	Hayashi Nakamura	Inoue Hirata	Konishi*
4th week (Mon-Fri)	Hayashi Hirata	Konishi* Nakamura	Inoue

NOTES:

1) The above assignment is planned considering the possibility of JFCU use during the 3rd - 4th weeks. JAERI personnel will work on FCU/JFCU and ISS including Raman and GCs. (Basically, Hayashi/Konishi/Inoue will cover JFCU/FCU and Nakamura/Hirata will cover ISS/Raman/JVAC.) If JFCU will not be used during the 3rd and 4th weeks, then JAERI shift assignments will be changed for that period. Any change will be covered in a Work Instruction.

2) * Konishi-san will be coming to TSTA from Apr. 24, 1992 and will participate in this extended loop run starting on Apr. 26, 1992 (Sunday: JFCU/ISS run start).

The above assignments are for the duration of the run (April 20-May 15, 1992). We will minimize the number of changes of personnel among the three shifts. The Facility Operators will not change shifts unless some major event occurs necessitating the change. For the other personnel, changes may, and probably will, occur, but we will minimize the changes.

2.2.2 Attachment 2

TEST PLAN for ISS PORTION of EXTENDED LOOP RUN 92-3

1.0 PURPOSE

The purposes of this experiment are to:

- Demonstrate long term stable operation of the ISS;
- Obtain steady state composition profiles of all 4 distillation columns and especially columns containing high concentrations of tritium;
- Investigate transient operation of a series of cascaded columns;
- Study ISS - FCU/JFCU dynamics and changes of FCU/JFCU products on the stability of ISS operations;
- Cleanup PC's that contain impurities mixed with tritium and offload one or more PC's of high purity tritium;
- Test and evaluate ISS operator advisement software.

2.0 CONFIGURATION

The ISS will be used in its normal configuration using all 4 columns

3.0 SUBSYSTEMS AND SPECIAL MATERIALS REQUIRED

All TSTA systems should be available since this is a loop experiment. The RAMAN subsystem is especially required for composition analyses. It is anticipated that the ISS GC's will not be operated except perhaps occasionally for measurement of $^3He/^4He$ in the top of column H. No special materials are required.

4.0 PERSONNEL REQUIRED

As this is a loop experiment, all TSTA personnel will be on hand or on call. The facility will be staffed round-the-clock. In particular, ISS must be attended any time that changes in column conditions are implemented.

Key ISS personnel for this run are Robert Sherman, David Taylor, and Kazuhiro Hirata.

Key personnel for the Raman subsystem are Robert Sherman, David Taylor, Mary King, and Hirofumi Nakamura.

5.0 SCHEDULE

The operation of ISS will be directly affected by the operation of FCU and JFCU. TSTA now has two fuel cleanup systems, the MSB-based FCU and the permeator-based JFCU. Both of these systems will be used alternately during this test. Overall, the plan is to use FCU during the first week and JFCU during the second week for intensive testing. Then, during the third and fourth weeks of the run, FCU or JFCU will be used with little or no impurities addition. See the test outline section of Attachment 3 for the detailed FCU schedule and Attachment 4 for the JFCU schedule.

6.0 HAZARDS ASSOCIATED WITH THIS TEST

Since ISS will be used in its normal configuration, only the normal hazards associated with ISS are anticipated. These include:

Large amount of tritium will be encountered during this test as including a column inventory of 12-20 moles of tritium in the liquid phase. All tritium handling procedures will be followed. In addition the columns will contain a larger quantity of liquid deuterium.

Liquid nitrogen is used to cool the ISS radiation shield and the helium refrigerator.

7.0 DATA REQUIREMENTS

Data will be archived by MDAC and written in the ISS and/or RAMAN log book.

8.0 OUTLINE OF THE TEST

8.1 NORMAL ISS OPERATIONS

The ISS will always be operated within the safety limits defined in the most current revision of ISS safe operating procedure, TTA-OP- 103-12.

The Column H effluent gas will be monitored continuously by the Low Range 1- liter ionization chamber in order to have an accurate measure of the HT content of this product stream. Before opening CLHA to TWT, this monitor will be read locally at ISS and reported to the loop operator. Both the monitor reading and the scale setting should be read and reported. An acceptable tritium rate in the effluent stream to be sent to the TWT is below 100 μCi/min.

The week before this test the following should be accomplished:

- Evacuate ISS to 10 torr; backfill with helium to 800 torr
- Purge ISS GC lines
- Evacuate ISS to 10 torr
- Repeat ISS purge two more times
- The ISS and ISS-GAN will be left at 800 torr of helium
- Evacuate ISS vacuum jacket
- Evacuate ISS refrigerator vacuum jacket
- Evacuate ISS helium transfer line vacuum spaces
- Cool ISS with liq N_2
- Plug in liq N_2 level controller
- Evacuate ISS-GAN manifold
- Evacuate connecting lines to EXP-2
- Evacuate manifold and Raman cell in EXP-2
- Perform flow meter zero check
- Perform pressure check of ISS pressure gauges.

DAY 1

- Open all 6 helium flow control valves to ~50%
- Start helium refrigerator using two compressors
- Set helium temperature controller to 23K
- Evacuate helium in ISS to TWT
- Plug in all heater controllers to 117V AC raceway inside ISS control panel; check heater setpoints.
- As soon as UTB pressure is above that of ISS, open evacuation valves EVIA, EVDA, and EVTA.
- Fill Column H through EVHA from the U-Bed containing the least tritium
- When helium temperature reached 23K **and** column pressures are above 500 torr, lower refrigerator temperature to 17K
- When column I and/or column T show signs of liquid in the reboiler
- Close the helium flow valve on the packed section
- Energize reboiler heater to ~5 Watts
- When all U-Beds have been emptied, close all evacuation valves
- Establish TOTAL REFLUX mode by turning on reboiler heaters and setting reboiler power to values listed in Table Ia.
- Change over to LOOP FLOW mode by opening valves CLIC, CLDA, CLDB, CLTA, and CLTB.
- Establish conditions as given in Table Ia. See Note 1 to Table I.
    - ♦ If a lower flow regime is desireable due to interactions with the JFCU an alternate set of conditions from Table Ib can be used.

- In order to obtain good column profile measurements it is important to maintain the ISS as stable as possible. If column conditions must be changed, small increments should be made. If all column pressures are too high or too low, the best adjustment is made by changing the helium refrigerator control temperature, generally in steps of 0.1K.
- After stable operation of the loop has been acheived and analyses have been obtained, operating conditions may be changed in one of the following manners:
  (a) Increase or decrease Top Flow Rate. See Note 2 to Table I.
  (b) Increase or decrease Reboiler Power. See Note 3 to Table I.

Table Ia.
Initial ISS Conditions
(see Note 1)

		Column I	Column H	Column D	Column T
Pressure	Torr	860	830	800	800
Top Flow	$cm^3/min.$	1300	50	4750	4000
Feed Flow	$cm^3/min.$	6000	5050	5000	4700
Bottom Flow	$cm^3/min.$	4700	5000	250	700
Reboiler Power	Watts	35	20	10	15
Reflux Ratio		28	200	12	7

Table Ib.
Modified ISS FLOW Conditions
(see Note 1)

		Column I	Column H	Column D	Column T
Top Flow	$cm^3/min.$	867	33	3167	2667
Feed Flow	$cm^3/min.$	4000	3367	3333	3133
Bottom Flow	$cm^3/min.$	3133	3167	167	467
Reboiler Power	Watts	23	13	7	10

NOTES:

1) These conditions are approximate and final values can only be determined after Raman analysis of the actual ISS/CLIC feed stream.

2) In making changes by varying the flow rate it is important to take into consideration the effect of the resultant stream composition on succeeding columns in the cascade. For example, with a 1:1 D-T inlet ratio to column I, just about 24% of the flow would normally be extracted as a top stream. If the withdrawal ratio, top/bottom, is increased significantly above 0.24, DT is forced to appear in the top stream and hence into the feed of column H. Too large a feed of T-bearing components to column H will result significant HT appearing in the top of that column. If that situation occurs it will force a closure of valve CLHA (exhausting HD) to

prevent too much HT being discharged to the TWT. Recovery from such a situation may be extremely slow.

3) Varying the reboiler power will generally produce a smaller change, but one that may be more controllable.

4) Front panel Flow meters readout is in either liters/min or cm^3/min depending on the range; MDAC display is in cm^3/min.

DAYS 6-7

During weekend operations the ISS will be operated in **RECYCLE** mode as long as other subsystems are operative. If the TP3 system becomes unavailable, ISS operation will be switched to **TOTAL REFLUX** mode.

DAYS 8-13

Operations will proceed as for Days 2-5

DAYS 14-15

Operations will proceed as for Days 6-7. The Column H top flow may be varied as an experimental parameter between 50 cm^3/min. and 500cm^3/min. during the run.

DAYS 16-23

Operations will proceed as for Days 2-5. Flow regime may depend upon selection of FCU or JFCU.

8.2 COLUMN T DYNAMICS

Dynamic operation of column T will be observed by changing either:
- the relative top/bottom withdrawal ratio, F-CLTA/F-CLTB, or
- the reboiler power (W-HTTB).

During such observations **no changes** will be made to columns I, H, and D.

8.3 OFFLOADING TRITIUM FROM ISS

At times during the run it will be desirable to remove one or more PC's of pure T_2 from the loop obtained from the reboiler of column T. This is done by:
- Analyze reboiler of column T to ascertain tritium purity,
- Evacuate lines from CLTB to a PC attached at LIO,

- Fill *ca.* 50 torr of T_2 into the PC,
- Pump PC and lines through TP1 back into the loop in order to flush the PC and lines,
- Fill PC to *ca.* 750 torr,
- Close PC valve, pump lines back into the loop, and remove PC,
- Place empty PC on station at LIO.

8.4 RAMAN OPERATIONS

After a stable profile has been obtained, the conditions in column I will be changed by readjusting the ratio of top/bottom flow, and measuring the top product (AN-1) every two minutes for 2 hours with the Raman system. After returning to the initial conditions and reaching equilibrium, a second change will be made by reducing Column I reboiler heater power to 20 watts.

Changes in column T will be observed in a similar manner except that column T top (AN-8) or bottom (AN-11) will be sampled.

When ISS transients are not being observed, the Raman system will be available to observe transients in the ISS feed (CLIC).

During transient condition measurements only Raman measurements will be made as the GC requires too much time.

When making a Raman measurement, the column conditions will be recorded manually on the data sheets and in the RAMAN LOG BOOK. Record at least the following information:

Date and Time
Column Identification
Column Pressure
Differential Pressure
Top Flow
Feed Flow
Reboiler Flow
Reboiler Power
Liquid Level

9.0 CALIBRATIONS

Prior to the run the following MDAC parameters and their associated instruments will be checked and calibration procedures implemented if necessary. Unless otherwise inicated they are all associated with the ISS subsystem (ISS-) (Procedure TTA-CP-103-02)

PRESSURE

Zero:	800 torr:	End-to-end MDAC check
P-CLIA	P-CLHA	YES
P-CLHA	P-CLHA	YES
P-CLDA	P-CLDA	YES
P-CLTA	P-CLTA	YES
P-CLID		YES
P-CLHD		YES
P-CLDD		YES
P-CLTD		YES
TP1-P-TP1DS		YES
TP1-P-TP2DS		YES
TP3-P-IMS		YES
TP3-P-NBI		YES
TP3-P-T2		YES
TP3-P-TP1		YES
TP3-P-DIS		YES
TP3-P-FCU		YES

FLOW

Zero and span:	End-to-end MDAC check
F-CLIA	YES
F-CLIC	YES
F-CLIB	YES
F-CLHA	YES
F-CLHB	YES
F-CLDA	YES
F-CLDB	YES
F-CLTA	YES
F-CLTB	YES
F-D2IN	YES
UTB-F-UB1	YES
UTB-F-UB2	YES
UTB-F-UB3	YES
UTB-F-UB4/5	YES

TP3-F-DIS	YES
TP3-F-DT	YES
TP3-F-NBI	YES
TP3-F-T2	YES

RADIATION

Zero and span:	End-to-end MDAC check
R-CLHA	YES
R-CLDA	YES

LIQUID LEVEL

Zero and span:	End-to-end MDAC check
Q-CLI	YES
Q-CLH	YES
Q-CLD	YES
Q-CLT	YES

10.0 ISS ADVISER SOFTWARE CHECKOUT

Prototype software (ISS Adviser) developed to assist operations personnel in adjustment of column control parameters will be tested during the current run. The software will be loaded into a laptop computer for use in the control room or at the local control panel. Operators and staff are requested to use the Adviser when adjusting ISS controls. A log shall be kept detailing information requested from the Adviser and responses obtained when inappropriate advice is given.

2.2.3 Attachment 3

TEST PLAN for FCU PORTION of EXTENDED LOOP RUN 92-3

1.0 PURPOSE

The purpose of this experiment is to:

- Demonstrate the use of the new Mg beds during a loop experiment,
- Demonstrate the complete FCU cycle including MSB loading/regeneration and DTOF loading/regeneration during a loop experiment,
- Demonstrate the use of FCU over an extended period of time, and
- Cleanup PC's that contain impurities mixed with tritium.

At least part of this test will be done with oxidizable impurities

2.0 CONFIGURATION

FCU will be used in its normal configuration except that the uranium hot metal beds are now replaced by two Mg hot metal beds.

HMB4 has been replaced by a shunt (tubing) so that that path may be used. The tubing leading to the position formerly occupied by HMB5 has been capped.

Also a new line and manual valve (MSBBY) is added allowing MSB1 and MSB2 to be operated in series when breakthrough of one bed is imminent.

If time permits, a new 0-20 SLPM flowmeter will be added in the path leading to CR2 from MSB1,2.

3.0 SUBSYSTEMS AND SPECIAL MATERIALS REQUIRED

All TSTA systems should be available since this is a loop experiment. Special material required for FCU will be 5%O_2/He used for oxidizing impurities, and H_2/D_2 and He used for purge gas. New O_2 analyzer cells (A5PM50) should be on hand. Impurities gas (10% CH_4/90% N_2) will be used to add impurities to the loop gas at TP3.

4.0 PERSONNEL REQUIRED

As this is a loop experiment, all TSTA personnel will be on hand or on call. The facility will be staffed round-the-clock. In particular, FCU must be attended any time that LN_2 is being used to cool FCU components.

Key FCU personnel for this run are Rick Wilhelm, Masahiko Inoue and Scott Willms.

5.0 SCHEDULE

TSTA now has two fuel cleanup systems–the MSB-based FCU and the permeator-based JFCU. Both of these systems will be used alternately during this test. Overall, the plan is to use FCU during the first week and JFCU during the second week for intensive testing. Then, during the third and fourth weeks of the run, FCU or JFCU will be used with little or no impurities addition. See the test outline section for the detailed FCU schedule.

6.0 HAZARDS ASSOCIATED WITH THIS TEST

Since FCU will be used in its normal configuration, only the normal hazards associated with FCU are anticipated. These include:

Large amount of tritium will be encountered during this test as nominally 50% tritium flowing at 6 SLPM will be processed by FCU. All tritium handling procedures will be followed.

Oxygen addition will only be in the form of 5% O_2/He to prevent the possibility of forming combustible mixtures.

Liquid nitrogen is used to cool the FCU components. A leak or rupture from an LN_2 line could over pressure the glovebox. The pressure of the glovebox is monitored by MDAC and an over pressure of the box will be enunciated with an alarm. Should this condition occur, the LN_2 should be turned off. This may be done either from MDAC or from the FCU control panel. Because of this hazard, LN_2 will not be left flowing in the FCU glovebox when it is unattended.

Magnesium will readily burn when exposed to oxygen while hot. Before being heated, the Mg bed must be flushed with He. **The 5% O_2/He used during parts of this test must not be admitted into the Mg bed at any time.** All oxygen must be evacuated from the regeneration train before use of the Mg bed is begun.

At 480 K Mg has a vapor pressure of 0.03 torr. For this reason, a vacuum should not be applied to the Mg bed (except momentarily) when it is at its operating temperature.

Emergency procedures for this test will be posted on the FCU glovebox.

7.0 DATA REQUIREMENTS

Data will be archived by MDAC and written in the FCU log book.

8.0 OUTLINE OF THE TEST

The week before this test the following should be done:

- Regenerate all MSB's.
- Both Mg beds should be purged with He, evacuated at room temperature and isolated.
- Check out the O_2 analyzer.
- Check that the FCU GC is operating properly.
- Transfer the contents of a number of PC's into the UTB standard volume. This gas will be used to preload FCU MSB's. See the overall loop plan for the details of this step.
- Become familiar with the new FCU configuration–HMB4 shunt, MG1 and MG2, new regeneration flowmeter.

8.1 WEEK 1

The most intensive FCU testing will be performed with the heaviest load of impurities encountered. The steps involved during this week are (days are given for reference only–actual days on which operations are performed may vary from that shown):

<u>DAY 1</u>

Heat CR1 to 450K, cool MSB1 and MSB3 to 77 K and cool MSBF1 to about 160 K.

Preload MSB1 with the standard volume gas. This gas must flow into FCU through CR1-MSBF1-MSB1.

Zero all FCU flowmeters.

Anytime after MSB1 has been preloaded, cool MSB2 to 77 K and MSBF to about 160 K. Preload MSB2 with gas from the UTB standard volume.

DAY 2

When ISS and other TSTA subsystems are ready, start flowing FCU main flow through CR1-MSBF1-MSB1 and NBI flow through MSB3.

Start impurities flowing into TP3.

Start GC sampling at the 3/4 point of MSB1 looking for impurities passing that point.

When impurities have passed the 3/4 point of MSB1, use the new MSBBY valve to start flowing through MSB1 and MSB2 in series.

DAY 4

Start GC sampling from the exhaust of MSB1.

When MSB1 breaks through completely start flowing through MSBF2-MSB2 alone.

Regenerate MSB1 to CR2-DTOF.

Start GC sampling from the 3/4 point of MSB2.

When impurities have passed the 3/4 point of MSB2, use the new MSBBY valve to start flowing through MSB2 and MSB1 in series.

DAY 5

Start GC sampling from the exhaust of MSB2.

When MSB2 breaks through completely start flowing through MSBF1-MSB1 alone.

Discontinue impurities flow into the loop at TP3.

Regenerate MSB2 to CR2-DTOF.

Regenerate the DTOF using the Mg bed to recover Q_2 from the water. This recovered Q_2 may be returned to the loop through the FCU-GAN using the metal bellows pump there if needed.

DAY 6,7

Flow is to continue through MSB1 with no impurities added to the loop. Minimal FCU action should be required at this time.

8.2 WEEK 2

FCU will be put into a standby mode as JFCU will be brought online. The only FCU work will focus on transfer the fuel cleanup tasks to JFCU and maintaining FCU in a standby mode. NBI flow will continue through the FCU MSB3 line during all extended loop run operations.

DAY 1

When flow is begun through JFCU, close the FCU valve which exhausts gas to ISS (ISS5). Do not close any other valves.

With the concurrence of JFCU personnel, MSB1 and MSBF1 may be allowed to warm to room temperature. This will allow gas from MSB1 to expand out of the FCU main inlet and into JFCU. After this operation is complete FCU may be isolated from the loop. This step is optional. It may be preferable to keep MSB1 and MSBF1 cold during all JFCU operations so that they will be available immediately if needed.

DAY 4

If MSB1 was warmed: With FCU isolated from the loop, cool MSBF1 to 160 K and MSB1 to 77 K. In this fashion MSB1 will adsorb and impurities which may have collected in FCU during its shutdown. With no impurities being added to the loop, open the FCU main feed to the loop and using manual valves throttle loop gas into FCU to preload MSB1.

Coordinating with JFCU, switch loop flow from being through JFCU to being through FCU.

DAYS 5-7

Maintain loop flow through FCU with no impurities being added to the loop.

8.3 WEEK 3

Continue to maintain loop flow through FCU. During this time additional PC's may be attached to LIO and emptied directly into the loop using the TP1 pumps. FCU will collect the impurities from these PC's. No addition impurities addition to the loop from IMS (other than H_2 and/or He) is planned during this time. Periodic GC samples may be taken from the MSB1 3/4 point to ensure that excessive impurities are not building up. NBI flow will continue through the FCU MSB3 line.

8.4 WEEK 4

Loop shutdown will occur. Until the middle of the week continue to maintain loop flow through FCU. PC addition may continue during the beginning of the week. If a significant amount of impurities have accumulated on MSB1 (ie. PC's were added to the loop while MSB1 was in service), N_2 or Ar must be used to displace the remaining Q_2 on MSB1 before it is regenerated. Periodic GC samples may be taken from the MSB1 3/4 point to ensure that excessive impurities are not building up. NBI flow will continue through the FCU MSB3 line.

DAYS 1,2

Continue as during week three.

DAY 4

Loop shutdown will occur.

If significant impurities have collected on MSB1 a full regeneration cycle using CR2/DTOF/MG1,2 will be required. In this case, prior to shutdown, N_2 or Ar must be added to the loop flow to intentionally fill MSB1 with impurities. Though MSB1 should not breakthrough completely, it should be taken as close as possible to complete breakthrough. This will displace the remaining Q_2 on MSB1 so that it will not be oxidized and reduced, producing unnecessary oxidized Mg. When this is complete, shutdown may proceed.

Gas from ISS will be transferred to UTB.

If MSB1 is full of impurities, a complete regeneration cycle will be necessary including regeneration of MSB1/MSBF1 through CR2-DTOF followed by regeneration of the DTOF through one of the MG beds. Loop gas may be pumped through the DTOF during its regeneration of avoid the addition of carrier gas.

When transfer of gas from ISS to UTB is nearing completion, all remaining cold FCU components (MSBF1?, MSB1? and MSB3) may be discontinued. **Provide a path for the gas evolving from these components to enter the loop** and then to UTB.

Heat MSBF1, MSB1 and MSB3 to 400 K.

Evacuate the FCU main flow and NBI paths to the loop using TP1. From the loop this gas will be transferred to UTB.

Isolate FCU and secure all components.

2.2.4 Attachment 4

TEST PLAN for JFCU PORTION of EXTENDED LOOP RUN 92-3

1.0 PURPOSE

This test plan describes the test of the JAERI Fuel Cleanup System (JFCU), interconnecting to the Isotope Separation System (ISS) during the Extended Loop Run. The objectives of this run are :

- to study the interaction between the ISS and the complete JFCU, (The effect of flow and pressure fluctuation generated by the ISS on the JFCU is of interest.)
- to demonstrate the capability of the JFCU to produce a hydrogen isotope stream for feed to ISS and to process impurities simulated from torus evacuation,
- to compare the JFCU and TSTA Fuel Cleanup System (FCU) in the same loop configuration and with the same hydrogen isotope / impurities composition,
- to check the effect of JFCU inventory on the total loop inventory, and
- to accumulate TSTA loop operation experience with the JFCU.

2.0 CONFIGURATION

The fuel circulation loop will be established through Transfer pump system No.1 (TP1) - JFCU - ISS - Transfer pump system No.3 (TP3), as shown in the attached Appendix A. Tritium is supplied from Uranium Tritide Beds (UTB) to the loop. No addition of tritium from a Product Container (PC) is planned. The ISS will be operated with 4 columns. The JFCU will be operated with the "External mode" of Cold Trap (CT) regeneration and the "Internal mode" of JFCU Catalytic Reactor No.1 (JCR1) dilution. (The same operation as the JFCU D_2 stand-alone run during April 1992.) Helium at 6-7 Nl/min[1] exhausts constantly to Tritium Waste Treatment system (TWT) as a carrier gas for CT regeneration, including a small amount of impurity. Exhaust from JFCU gas chromatographs (GCs) will also be sent to TWT. Impurity addition should not be attempted until stable operation of the JFCU and all four ISS columns has been acheived.

Primary choice of impurities is mixture of 10% CH_4 in nitrogen into the JFCU-Reservoir Tank No.1 (RT1), because they are expected to make a little impact on the loop operation.

(The Raman system in EXP2 Glove Box (GB) will be used to measure the dynamic response of the ISS. The Raman sample gas will be returned to the FCU.

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[1] Nl/min = standard liters per minute.

3.0 SUBSYSTEM REQUIRED

Safety subsystems Process Evacuation system (PEV), TWT, Secondary containment (SEC), Tritium Monitoring (TM), Building Ventilation (VEN), House Vacuum (VAC), Master Data Acquisition and Control (MDAC), and Utilities (UTIL) should be operational. The MDAC System will archive data from the process and receive data from the JFCU. The JCR1 outlet O_2 concentration or O_2 flow at the inlet of the JCR1 is also controlled through the MDAC. Interlocks (alarm and "scram" signal from MDAC) will be set using the JCR1 inlet oxygen concentration and the water decomposition current of Ceramic Electrolysis Cell (CEC) as the monitored variables. Alarms from differential pressure of CEC tubes, dew point of CEC inlet, and CT regeneration flow rate will be also set in the JFCU SAFETY program at the MDAC.
(A part of the FCU will be used for the return path through of the Raman gas.)

4.0 PERSONNEL

Both JAERI and TSTA personnel will be consulted prior to any major decision on the system operation. Operation of the JFCU will be performed by LANL operator(s) with the close collaboration of JFCU-qualified JAERI staff and knowledgeable TSTA staff. The appropriate JAERI staff are Konishi, Hayashi, and Inoue. One of these three must be working with a LANL operator at the JFCU control console at all times. Any operations or system adjustments of any kind, must be communicated to this operator before being done. Operations of the ISS will be performed by operators under the supervision of knowledgeable TSTA and JAERI staff at the control room.
Refer the Assignment plan (Attachment 1).

5.0 TIME

The run of the JFCU part will be conducted for 7 days, around-the-clock operation including 6 night shifts.

This JFCU part starts by cooling down and heating up of the components of the JFCU on the first day. At that time, the ISS will have been cooled down and liquid hydrogen isotopes will also have been supplied to the ISS.

At the 2nd day, the JFCU-ISS connection will be started and continued through the 4th day. The main experiments of the JFCU part will be performed during 2nd - 4th day.

At the 5th day, the JFCU will be isolated from the ISS and hydrogen isotope gas (DT mixture) in the RT2 will be recovered by JFCU-Zirconium Cobalt Bed No.1 (ZCB1) and dry-up operation will also start, recovering DT mixture in the JFCU to ZCB1. At that time, the ISS will be in the total recycle mode using the JFCU bypass line (HV-A,B,C line of the JFCU) or in the TOTAL REFLUX mode or the RECYCLE mode through FCU.

The JFCU component heating and cooling will be stopped in the 6th day, depending on the dry up situation of the JFCU. The cooling water for the CEC will be stopped in the 7th day. If the JFCU will be use again in the following week for the stable loop operation, the JFCU component will be kept at operating temperature except CT.

The tritium inventory of the JFCU will be measured after the whole extended loop run.

This run of the JFCU part will start on April 26, 1992. (Sunday)

6.0 POSSIBLE HAZARDS AND EMERGENCY CONCERNS

Approximately 100 grams of tritium will be used in the test. The tritium inventory of the JFCU during this run is estimated to be about 5 ~ 6 grams based on the last integrated loop run (Run 91-3). Off-normal situations in a run have already been considered in the SOP for ISS and JFCU. Interconnecting the JFCU and the ISS could lead to problem not previously experienced. Both the ISS and the JFCU are independently interlocked for emergency situations. When one system alarms, the other can detect it by an MDAC alarm. Consideration of value of tritium and the desire to minimize tritium waste requires that there be a limit on the amount of tritium sent to the TWT. This is addressed in the main test plan. The run will also be halted if during the run fluctuations become sufficient that the ISS safety program opens EVAC valves and dumps to UTB. If JFCU goes into PAUSE mode during the C shift, the loop operation will not be restarted until the following morning when more personnel are again available.

7.0 OUTLINE

7.1 PREPARATIONS

1) Install new application software for the JFCU and check the function concerning important interlock/alarms.
2) Connect impurity supply cylinder to the CH_4 (HV005-AV003) line.

7.2 RUN

DAY 1

The JFCU computer will be started and components (Palladium diffuser (PD), JCR1, CEC) will be heated by procedure (TTA-TP-118-15,Current Revision). CTs will be cooled down. Mass flow meter/controllers and pressure sensors zero adjustment will be carried out after evacuation of JFCU and isolation of the CEC and O_2 sensors. O_2 sensors will be calibrated in accordance with the operating manual. The JFCU SAFETY program will be start on MDAC. During these preparations, ZCB1 will be regenerated, sampled for an inventory check, and the hydrogen isotopes will be stored on RT2. The stored isotopes will be absorbed back onto ZCB1 after it is cooled down. During the night JMSB3, 4, and 5 will be regenerated by evacuation via TMP of JFCU. After stopping impurity injection during the FCU part of this run, residual impurity in the loop line will be removed completely by the FCU. Then ISS and FCU will be isolated. The FCU will be keep situation (keep low temp. of Molecular sieve bed (MSB)) until the complete preparation of the JFCU.

DAY 2

The ISS will first be operated in either **TOTAL REFLUX** mode or **TOTAL RECYCLE** mode with FCU. The JFCU is isolated and become in a stand-by mode where helium, as the carrier gas of Cold Trap (CT) regeneration, will be supplied to the JFCU. O_2 concentration for JCR1 will be adjusted and these gas will be exhausted to the TWT. (At this time, CT regeneration mode is "External" and JCR1 dilution mode is "Internal".)

(1) **Open** AV412. **Open** AV409 and **close** AV 431.

(2) **Adjust** CT regeneration ^{4}He flow rate. **Start** O_2 control program from MDAC.

(3) **Check** the cold trap cycle = "START"(PC), **Set** O_2 conc. of JCR1OUT at ~2% (by manual adjustment),
Monitor the Ceramic Electrolysis Cell potentiostat is "on" and outlet pressure of TP1 > PRA-RT1.

The JFCU parameter setting (following TTA-TP-118-20, current revision) will be checked and adjusted. Then,

(4) **Check** that AV404 and AV406 are closed.

(5) **Open** hand valves HV-A, HV-B, and HV-C (as shown in Appendix A).

(6) **Check** the situation of the outlet lines of ISS - TP3 - TP1 - JFCU HV-A,B,C line - feed line of ISS.

(7) **Start** circulation of ISS using the HV-A,B,C line of JFCU (ISS-TP3-TP1-JFCU HV-A,B,C line - ISS).

Nominal ISS operations will be in general accordance with the following, Feed flow (Loop Flow) is 6 Nl/min and column pressure is 860 torr. However, starting loop flow will be adjusted as low as possible.(3~4 Nl/min) After connection between the JFCU and the ISS, loop flow will be increased to the normal flow. When the ISS circulation is stabilized, After checking the above JFCU conditions, start the gas processing at the JFCU.

(8) **Close** HV501. Then **open** AV404. **Check** again the above pressures. After checking the JFCU process oxygen conc. again, which will be controlled by MDAC,

(9) Slowly **open** HV501.
(10) **Close** slowly HV-B, checking JFCU system parameters.

When the pressure of JFCU-RT2 increase to about 860 torr,
(11) **Open** AV406 and **check** the value of PRA-RT2, PRCA-ISSIN, and FR-ISSIN.
(12) **JFCU-GCs are started.** Sampling program will be used Type I (sampling point #2,#3, and #5), as shown in the TTA-TP-118-20, current revision.

Flow rate of the loop will be controlled by the controller in the ISS (F-CLIA, Q-CLI, and/or F-CLTB etc.). JFCU processing gas flow rate could be controlled by adjusting the HV-B, however, it is difficult. Some difficulty is anticipated to balance and stabilize system pressure and flow rate. Try to increase loop flow.

DAY 3

After checking the stabilization of JFCU-ISS loop, impurities will be added at the JFCU (inlet of JFCU-RT1) **(and also regeneration gas from FCU will be acceptable)**.
(13) **Adjust** impurity flow setting by JFCU-PC.(~ 0.1 Nl/min)
(14) **Close** HV005.
(15) **Open** AV403 which connects N_2/CH_4 cylinder.
(15) **Open** slowly HV004 and/or HV005. Check these impurity flows by JFCU-PC.

During stable operation, it is important to maintain the ISS as stable as possible, in order to check the processing capacity of the JFCU-PD as well as to obtain good column profile measurements.

DAY 4

Continue the loop run as same as the third day with impurities injection.

DAYS 5, 6, AND 7

JFCU will be isolated by AV 404 and AV406 and the JFCU shut-down procedure will be started. (JFCU recovery procedure is well described in TTA-TP-118-15.) One day (day 5) will be required to decompose most of the residual water in the JFCU process. Tritium in the JFCU will be recovered on ZCB1. During day 6, JFCU component heating and cooling will be stopped after when the dry up operation finished. When all hudrogen isotopes have been removed (dry up), the JFCU component cooling water flow will be shut off in the 7th day.

FOLLOWING WEEK DAYS

If the JFCU-ISS loop operation is stable enough, we will plan to use JFCU during part of following weeks loop operation. However, if JFCU should be shut down completely, two days will be required for the complete dry up the JFCU systems. In order to complete the shut down on Friday, JFCU shut down operation should be started during the "A" shift on Thursday.

7.3 OFF-NORMAL CONDITIONS

JFCU

Conditions that may lead to large losses of tritium to TWT from JFCU will be detected by the JFCU process tritium monitor and PEV tritium monitors and initiate interlocked "pause mode". (All boundary valves close, all pumps turn off, and the temperature of each component and cycle of JFCU-CT will be maintained.). In this case, supply of DT from JFCU to ISS stops. JFCU is isolated. If the HV-B is left closed, TP3 will be turn off by its own interlock (TP3 discharge press. high). HV-B shown in Appendix A. All staff and operators should know the actual location of this valve in the JFCU-GB, prior to start of the run.

When "pause" is initiated,

(1) **Open HV-B as soon as possible.**

(2) **Turn on** TP3, if needed.

(3) **Identify and correct** the problem that caused interlock. Then, JFCU re-start will proceed as follows.

Operations will be done step by step and will not need to be hurried. (Basic JFCU re-start procedure is same of TTA-TP-118-15, Current Revision.)

(1) **Turn on** the Booster pump (BP) and Scroll pump (Scroll).

(2) **Open** HCV575 and **Turn on** the Metal Bellows pump (MBP).

(3) **Adjust** HCV575, checking the pressure of PRC-JFCUEX (< 1000 torr). **Circulate** gas around JCR1 using internal JCR1 dilution line to recover tritium to CT in this section.

(4) **Take** sample from #5 sample location and **Check** tritium elimination.

(5) **Open** AV412, AV410 and **Close** AV430 to purge this line and to **calibrate** O_2 sensor if needed. **Wait** until O_2 conc. of ORA-JCR1IN stabilized below 5 % and **Open** AV411.

(6) **Check** CEC line pressure (open AV415) and **Open** AV414 during this purge.

(7) **Open** AV409, AV430 and **Close** AV410 (started CT regeneration ^{4}He flow "External" and JCR1 dilution "Internal").

(8) **Check** system pressure (PDEX press. control) and **adjust** flow again
(9) **Start** CT cycle operation
(10) **Set** JFCU Safety program "OFF", CEC potentiostat "ON" and then set the JFCU Safety program "ON" again.
(11) **Set** the cold trap cycle to "**START**"(PC). **Do not set to "RESET"**.
(12) **Open** AV406 and **check** the value of PRA-RT2 and PRCA-ISSIN. After adjusting pressures (outlet pressure of TP1 > PRA-RT1),
(13) **Close** HV501. Then **open** AV404. **Check** again the above pressures. After checking the JFCU process oxygen conc., which will be controlled by MDAC,
(14) Slowly **open** HV501,
(15) **Close** slowly HV-B, checking JFCU system parameters. (PRA-RT1, PRA-RT2, FR-PDIN(CECEX), ORA-JCR1IN, ORCA-JCR1EX, RRA-TWTIN, etc.) If this pause is initiated during impurity injection,
(16) **Open** AV402 and/or AV403 which connected ^4He and/or N_2/CH_4 cylinder.

8.0 DATA

Data will be recorded in the MDAC computer archive file, JFCU computer, and each GC. JFCU logbooks will be used for the formal logging of the operation in addition to the MDAC logging. All the major operations will be recorded in a notebook in control room by the loop operator.

When making a GC measurement of the JFCU, the following data will be recorded manually in the JFCU LOG BOOK.

- Program timer setting information
- Start time of the program timer and sampling point selection
- Sampling gas pressure of each sampling point (if possible)

All data will be documented and maintained in accordance with Records Control Procedure TTA-QP-10, Current Revision.

9.0 CALIBRATIONS

1) O_2 sensors calibration
2) GC calibration check
3) Pressure sensors and Mass flow meters/controllers "zero" adjustment

The above calibration will be complete in the first day or 2nd day morning of the JFCU part run.

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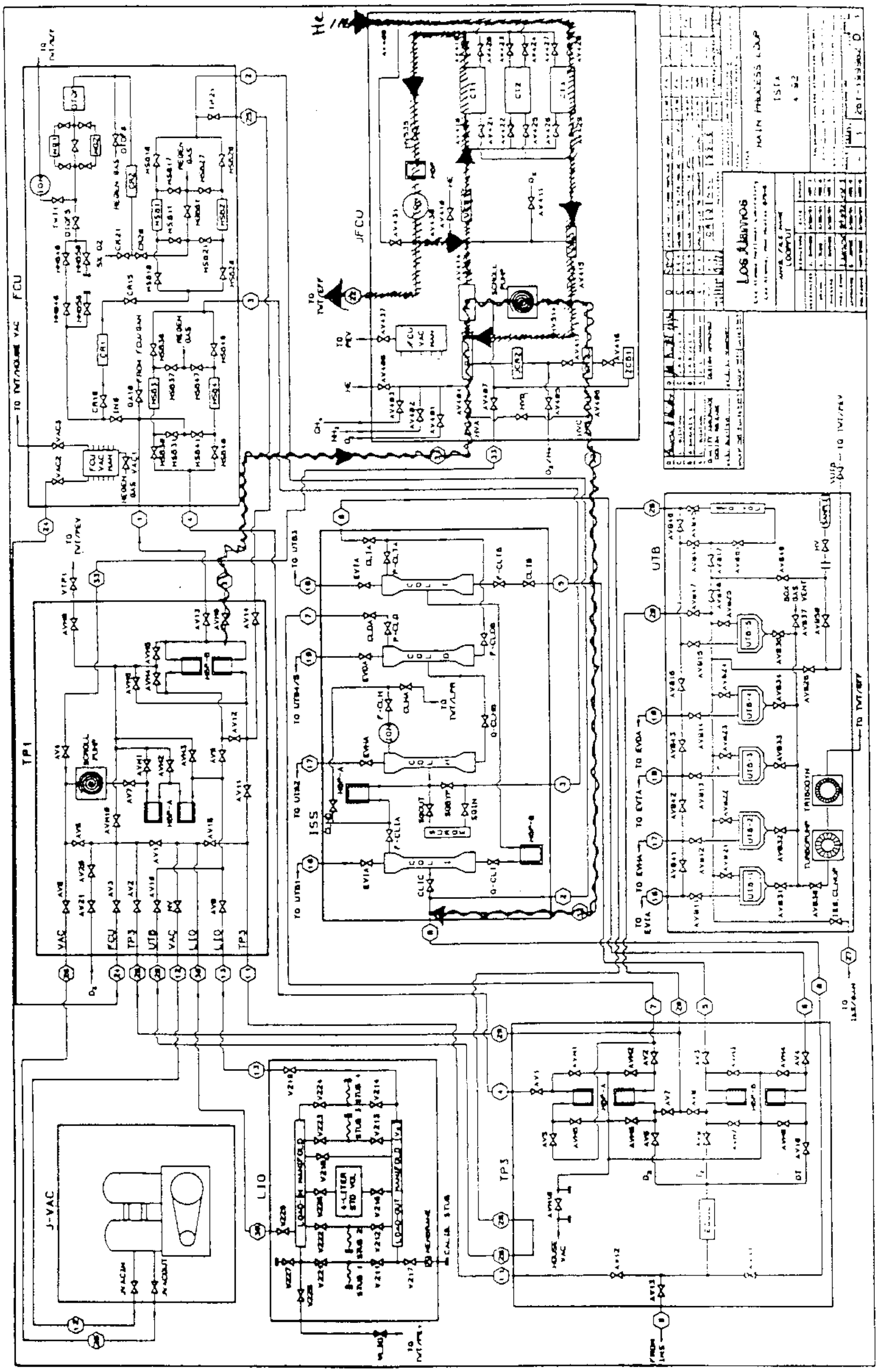
Attachment 4



Appendix A

2.2.5 Attachment 5

TEST PLAN for JVAC PORTION of EXTENDED LOOP RUN 92-3

This test plan describes the testing of the JAERI AUXILIARY VACUUM SYSTEM (JVAC) with the Tritium System Test Assembly (TSTA) loop. This is the first test for JVAC to use tritium.

1.0 PURPOSE

The main purposes are :

- to circulate the TSTA loop using JVAC instead of Transfer Pumping Unit (TPU) and,
- to measure characteristics of the JVAC using Q_2 (including tritium).

2.0 CONFIGURATION

The test will be conducted using the Isotope Separation System (ISS), Transfer Pumping Unit 3 (TP3)-Transfer Pumping Unit 1 (TP1)-JVAC-TP1-Fuel Cleanup (FCU) or JAERI Fuel Cleanup (JFCU) as shown in Appendix A. Process and vacuum exhaust will be processed by the Tritium Waste Treatment system (TWT) since all gas will be contaminated with tritium.

3.0 SUBSYSTEMS REQUIRED

The ISS, TPU and FCU or JFCU will be needed for loop operation. The Master Data Acquisition and Control (MDAC) will archive data. PEV and TWT will process exhaust from experimental lines. Nitrogen, chilled water, helium, and electric power are needed.

4.0 PERSONNEL

H. Nakamura and J. Nasise will coordinate the test. All the JAERI members and a number of Tritium Systems Test Assembly (TSTA) staff, operators are involved in the testing. TSTA operators will conduct the operation.

5.0 TIME

The test will start on May 11, 1992. It will require approximately three working days. Day 1 will be scheduled to start up JVAC and to connect it to the TSTA loop. JVAC will be used instead of TPU pumps. The rest of Day 1 and Day 2, 3 will be used to measure characteristics of JVAC as functions of flow rate and Q_2 composition.

6.0 POSSIBLE HAZARDS

Tritium is used in testing. If the process bellows fails, tritium would be released into the secondary containment and will be detected by the glovebox monitor at TP1. Failure Modes and Effects Analysis (FMEA) has been done for major components of JVAC. If needed, please refer System Design Description (SDD) of JVAC (TTA-SDD-119, R0).

Other potential hazards are high temperature of pump, pump bellows, high pressure gas and loss of cooling water and electric power. All major hazards are monitored and/or interlocked at local of JVAC. Operating ranges and safety limits are shown in table I.

TABLE I

OPERATING LIMITS OF JVAC PARAMETERS

MDAC Parameter	Local Parameter	Units	Normal Range	Alarm Setpoint	Alarm Action
	P-Inlet	Torr	0~10	-	-
	P-Disch	g/cm^{2}G	-1000~+1000	-	-
	P-Bellows	kgf/cm^2	0.3~0.5	0.2	Pump shut down
	T-Outlet	Deg C	20-60	80	Pump shut down
TP1-F-JVAC		Std l/min	0-30		

7.0 OUTLINE

7.1 Preparation

JVAC will be secured to the floor with anchor bolts. (See Appendix B)
Electrical power will be supplied (AC 208 Volt, 3-phase, 22 kW for main power and with AC 120 Volt, 1-phase for instruments).
Nitrogen gas will be supplied via TP1 pressure controller with 0.5 kg/cm^2 G (21.3 psi), about 20 NL for the bellows safety checking monitor.
Cooling water, with a flow rate of 5 L/min (< 298 K), will be supplied from TSTA cooling water system.
Motor rotation direction will be checked.
Mass flow controller will be installed in the TP1 glovebox.
The belt guard will be installed.
JVAC will be connected to the TSTA process lines with secondary containment lines.

Secondary containment lines will be helium leak checked.
Process lines and internal pump connection lines will be helium leak checked.
Tritium leak check will be needed for JVAC.
Pressure and flow meters will be calibrated.
Process will be evacuated.
Crank case bellow's pressure transducer will be interlocked with inlet and outlet valves.
Safety program will be installed in MDAC.

7.2 Test

JVAC will be connected TSTA loop by opening valves: AV5, AV6, AVM10, AVM6, AVM4, AV15 and MV at TP1. Main discharge valve of JVACOUT will be opened and verified. JVAC motor will be turned on. Inlet valve JVACIN will be opened. After confirming the aforementioned conditions, AVM3, AVM4, AVM7 and AVM8 at TP3 will be opened and MBP-B stopped at TP3. After AV11 and AV12 are closed, JVAC will be placed on-line instead of MBP-B at TP3. When stable operations are confirmed, data (Q_2 composition, flow rate, vacuum and discharge pressure etc.) will be taken. Changing the Q_2 composition and/or flow rate, characteristics of JVAC+MBP-B at TP1 will be taken. Ranges of Q_2 composition and flow rate are determined by current conditions of ISS and/or FCU or JFCU.

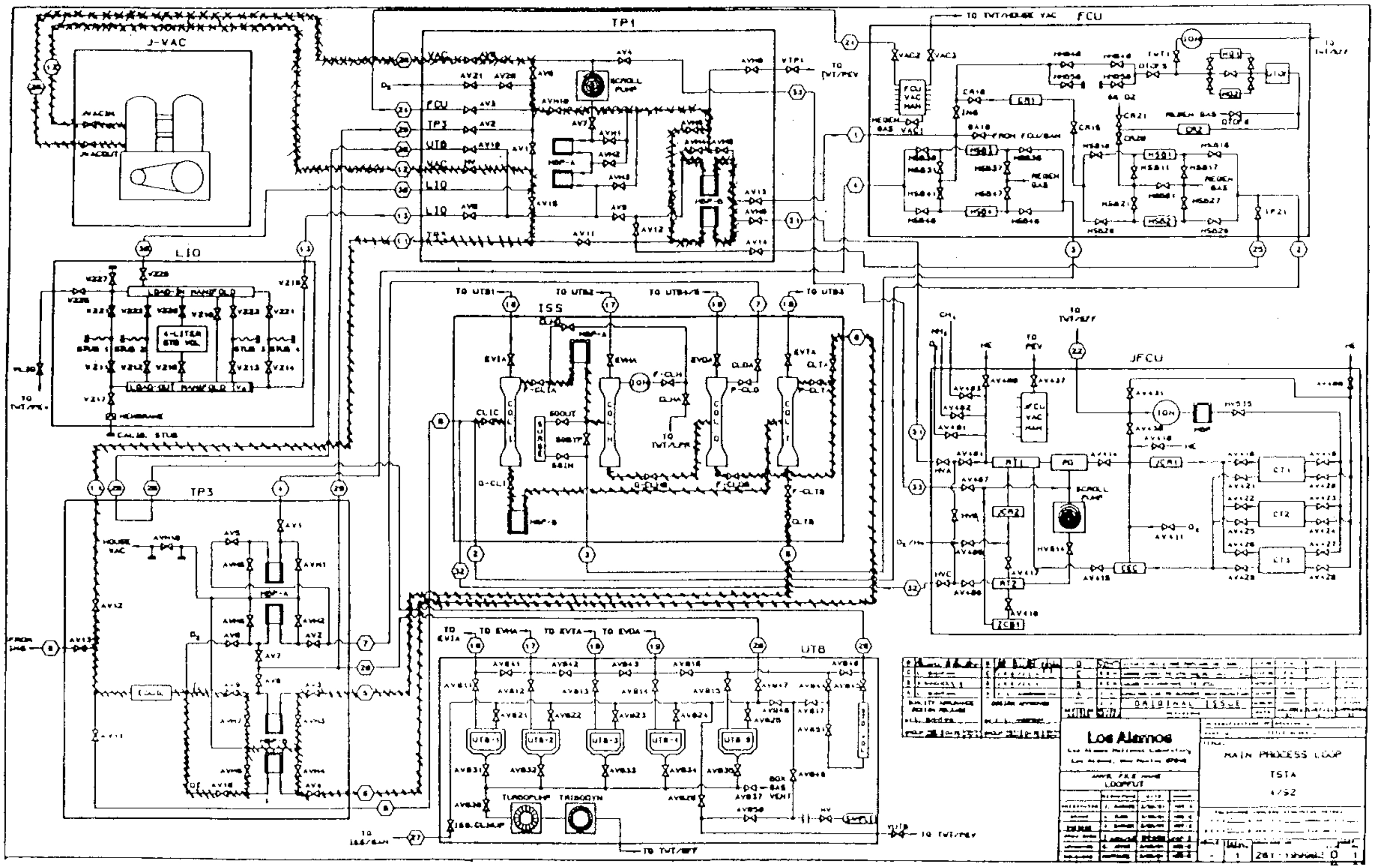
After the comparison data of JVAC+MBP-B are measured, AVM5 will be opened and MBP-B at TP1 will be stopped. If stable operations can be achieved, the characteristics of JVAC and MBP-B will be documented. If not, the MBP-B at TP1 will be started and used for the remainder of the run and long term tritium observation will be studied.

These operations will be done on the "A" shift. The "B" and "C" shifts will maintain stable operations.

8.0 DATA

Data will be recorded in the JVAC notebook. Discharge pressure, vacuum, and discharge temperature are indicated at JVAC control box. The other data can be taken by MDAC. Results of the test will be analyzed and reported.

Appendix A



Schematic of the Experimental Loop

Loop not using JVAC

Loop using JVAC

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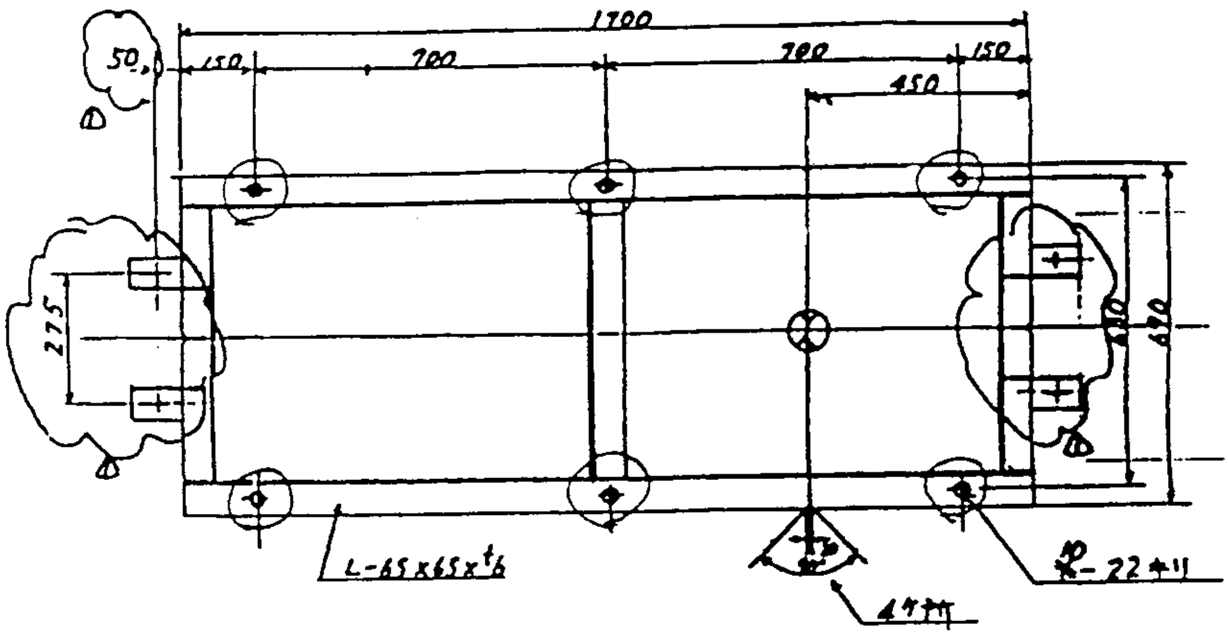
Attachment 5

Appendix B

Points to drive in the anchor bolts.



Anchor bolts : M20 x 170L x 6

2.2.6 Attachment 6

LIST OF PRODUCT CONTAINERS (PC) AVAILABLE SORTED BY TOTAL LITERS

Decayed Information:												
PC #	531	606	616	546	581	1101	810	662	904	664	1050	847
Moles:												
Total Moles (Start)	0.0000	0.0498	0.0726	0.1829	0.3420	0.4152	0.4396	0.5746	0.8008	0.8710	1.0307	1.0035
H	0.0000	0.0006	0.0226	0.0087	0.1599	0.0084	0.0098	0.0509	0.0035	0.3259	0.1567	0.0004
D	0.0000	0.0036	0.0327	0.0055	0.0838	0.0094	0.0909	0.0954	0.0228	0.4156	0.4950	0.0003
T	0.0000	0.0335	0.0040	0.1063	0.0774	0.0309	0.0435	0.0279	0.0067	0.0912	0.3429	0.8776
T (Decayed)	0.0000	0.0299	0.0038	0.1017	0.0690	0.0276	0.0388	0.0249	0.0059	0.0873	0.3339	0.8170
He-3	0.0000	0.0058	0.0020	0.0362	0.0204	0.3639	0.2079	0.0097	0.0854	0.0249	0.0052	0.1253
He-3 (Decayed)	0.0000	0.0130	0.0024	0.0454	0.0372	0.3706	0.2173	0.0158	0.0868	0.0327	0.0232	0.2463
He-4	0.0000	0.0052	0.0001	0.0000	0.0003	0.0006	0.0806	0.0000	0.2325	0.0006	0.0049	0.0000
CQ4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017	0.0000
Q2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0092	0.0000
N2	0.0000	0.0011	0.0111	0.0216	0.0001	0.0011	0.0066	0.3899	0.4440	0.0117	0.0072	0.0000
O2	0.0000	0.0000	0.0001	0.0044	0.0000	0.0002	0.0001	0.0002	0.0000	0.0010	0.0001	0.0000
Other	0.0000	0.0000	0.0000	0.0002	0.0000	0.0007	0.0002	0.0006	0.0058	0.0001	0.0078	0.0000
Total Moles (New)	0.0000	0.0534	0.0728	0.1875	0.3504	0.4185	0.4443	0.5777	0.8015	0.8749	1.0397	1.0641
New Grams:												
H	0.0000	0.0011	0.0456	0.0175	0.3224	0.0169	0.0198	0.1026	0.0071	0.6569	0.3158	0.0008
D	0.0000	0.0143	0.1317	0.0222	0.3374	0.0378	0.3663	0.3842	0.0919	1.6739	1.9939	0.0012
T (Decayed)	0.0000	0.1805	0.0231	0.6135	0.4163	0.1663	0.2341	0.1501	0.0358	0.5268	2.0142	4.9285
He-3 (Decayed)	0.0000	0.0784	0.0144	0.2741	0.2245	2.2354	1.3109	0.0954	0.5237	0.1973	0.1399	1.4860
He-4	0.0000	0.0210	0.0003	0.0000	0.0014	0.0023	0.3225	0.0000	0.9306	0.0022	0.0196	0.0000
CQ4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0265	0.0000
Q2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1660	0.0000
N2	0.0000	0.0319	0.3113	0.6036	0.0024	0.0296	0.1854	10.9196	12.4357	0.3271	0.2012	0.0000
O2	0.0000	0.0000	0.0025	0.1408	0.0000	0.0072	0.0023	0.0051	0.0000	0.0323	0.0033	0.0000
Other												
New Liters:												
H	0.0	0.0	0.5	0.2	3.6	0.2	0.2	1.1	0.1	7.3	3.5	0.0
D	0.0	0.1	0.7	0.1	1.9	0.2	2.0	2.1	0.5	9.3	11.1	0.0
T (Decayed)	0.0	0.7	0.1	2.3	1.5	0.6	0.9	0.6	0.1	2.0	7.5	18.3
He-3 (Decayed)	0.0	0.3	0.1	1.0	0.8	8.3	4.9	0.4	1.9	0.7	0.5	5.5
He-4	0.0	0.1	0.0	0.0	0.0	0.0	1.8	0.0	5.2	0.0	0.1	0.0
CQ4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0
N2	0.0	0.0	0.2	0.5	0.0	0.0	0.1	8.7	10.0	0.3	0.2	0.0
O2	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.2	0.0
Sum	0.0	1.2	1.6	4.2	7.9	9.4	10.0	13.0	18.0	19.6	23.3	23.9

Decayed Information:

PC #	648	567	1093	1132	1056	831	572	554	541	857	784	731
Moles:												
Total Moles (Start)	1.0829	1.1783	1.1856	1.1886	1.2105	1.2250	1.4271	1.4434	1.4659	1.5016	1.5678	1.6872
H	0.1048	1.0432	0.0005	0.4226	0.0016	0.1234	0.4971	0.0808	0.0380	0.4947	0.0055	0.5162
D	0.0836	0.1228	1.1768	0.0107	0.0085	0.0870	0.7103	1.0611	0.0786	0.7913	0.0163	0.8042
T	0.0421	0.0075	0.0039	0.0099	0.0076	0.0418	0.1904	0.0648	1.3255	0.1873	1.1454	0.0050
T (Decayed)	0.0375	0.0072	0.0035	0.0091	0.0068	0.0373	0.1697	0.0578	1.2950	0.1670	1.0963	0.0045
He-3	0.0224	0.0000	0.0040	0.0000	0.2320	0.1385	0.0249	0.2080	0.0164	0.0199	0.3769	0.0175
He-3 (Decayed)	0.0316	0.0006	0.0049	0.0017	0.2337	0.1475	0.0662	0.2220	0.0772	0.0606	0.4751	0.0186
He-4	0.0000	0.0015	0.0000	0.0329	0.0000	0.6725	0.0000	0.0254	0.0074	0.0000	0.0000	0.0054
CQ4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Q2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N2	0.8300	0.0028	0.0003	0.7125	0.9584	0.0927	0.0044	0.0020	0.0000	0.0070	0.0190	0.3300
O2	0.0000	0.0002	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001	0.0000	0.0013	0.0038	0.0000
Other	0.0001	0.0002	0.0000	0.0000	0.0023	0.0689	0.0001	0.0011	0.0000	0.0000	0.0008	0.0089
Total Moles (New)	1.0875	1.1785	1.1860	1.1895	1.2114	1.2294	1.4478	1.4503	1.4963	1.5219	1.6169	1.6878
New Grams:												
H	0.2112	2.1028	0.0010	0.8517	0.0033	0.2488	1.0020	0.1629	0.0766	0.9971	0.0111	1.0405
D	0.3366	0.4948	4.7406	0.0432	0.0341	0.3503	2.8611	4.2743	0.3166	3.1875	0.0655	3.2395
T (Decayed)	0.2262	0.0433	0.0210	0.0547	0.0408	0.2250	1.0237	0.3484	7.8118	1.0073	6.6132	0.0271
He-3 (Decayed)	0.1904	0.0034	0.0294	0.0105	1.4094	0.8899	0.3992	1.3394	0.4658	0.3654	2.8661	0.1123
He-4	0.0000	0.0060	0.0000	0.1316	0.0000	2.6918	0.0000	0.1017	0.0297	0.0000	0.0000	0.0216
CQ4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Q2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N2	23.2463	0.0792	0.0076	19.9551	26.8414	2.5952	0.1231	0.0558	0.0000	0.1968	0.5330	9.2415
O2	0.0000	0.0064	0.0000	0.0000	0.0031	0.0047	0.0000	0.0046	0.0000	0.0413	0.1219	0.0000
Other												
New Liters:												
H	2.3	23.4	0.0	9.5	0.0	2.8	11.1	1.8	0.9	11.1	0.1	11.6
D	1.9	2.8	26.4	0.2	0.2	2.0	15.9	23.8	1.8	17.7	0.4	18.0
T (Decayed)	0.8	0.2	0.1	0.2	0.2	0.8	3.8	1.3	29.0	3.7	24.6	0.1
He-3 (Decayed)	0.7	0.0	0.1	0.0	5.2	3.3	1.5	5.0	1.7	1.4	10.7	0.4
He-4	0.0	0.0	0.0	0.7	0.0	15.1	0.0	0.6	0.2	0.0	0.0	0.1
CQ4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q2O	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N2	18.6	0.1	0.0	16.0	21.5	2.1	0.1	0.0	0.0	0.2	0.4	7.4
O2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Other	0.0	0.0	0.0	0.0	0.1	1.5	0.0	0.0	0.0	0.0	0.0	0.2
Sum	24.4	26.4	26.6	26.7	27.2	27.6	32.5	32.5	33.6	34.1	36.3	37.9

Decayed Information:											
PC #	769	532	1031	675	672	570	724	1061	1046	995	1100
Moles:											
Total Moles (Start)	1.6909	1.7304	1.7246	1.7447	2.0265	2.1825	2.2054	2.2586	2.2798	2.5660	2.5693
H	1.1428	0.4983	0.3484	0.2270	0.0039	0.0002	0.0275	0.0013	0.0458	1.5681	0.2271
D	0.3630	1.1391	1.2728	1.3595	0.0217	0.0050	0.2028	0.0438	0.2847	0.8539	0.1466
T	0.1659	0.0027	0.0855	0.1026	1.4712	0.0186	0.0265	1.6310	0.4655	0.1022	0.0714
T (Decayed)	0.1479	0.0024	0.0763	0.0916	1.4480	0.0166	0.0259	1.6053	0.4152	0.0981	0.0683
He-3	0.0167	0.0043	0.0168	0.0539	0.5298	2.1225	0.0840	0.5786	0.1495	0.0000	0.0543
He-3 (Decayed)	0.0525	0.0049	0.0353	0.0760	0.5762	2.1265	0.0852	0.6300	0.2499	0.0082	0.0604
He-4	0.0003	0.0008	0.0000	0.0000	0.0000	0.0239	0.0000	0.0039	0.0000	0.0087	0.0000
CQ4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0176	0.0000	0.0257	0.0000	0.0000
Q2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0159	0.0000	0.0000	0.0000	0.0000
N2	0.0022	0.0821	0.0010	0.0017	0.0000	0.0096	1.8139	0.0000	1.2975	0.0314	2.0672
O2	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0016	0.0000	0.0080	0.0014	0.0018
Other	0.0000	0.0029	0.0000	0.0000	0.0000	0.0027	0.0155	0.0000	0.0032	0.0003	0.0008
Total Moles (New)	1.7088	1.7307	1.7339	1.7558	2.0497	2.1845	2.2060	2.2843	2.3301	2.5701	2.5723
New Grams:											
H	2.3035	1.0044	0.7022	0.4575	0.0078	0.0004	0.0554	0.0027	0.0923	3.1608	0.4578
D	1.4624	4.5886	5.1272	5.4763	0.0874	0.0203	0.8170	0.1765	1.1468	3.4396	0.5906
T (Decayed)	0.8924	0.0144	0.4603	0.5523	8.7346	0.1003	0.1562	9.6832	2.5048	0.5916	0.4122
He-3 (Decayed)	0.3169	0.0297	0.2129	0.4587	3.4755	12.8273	0.5142	3.8002	1.5076	0.0496	0.3644
He-4	0.0012	0.0032	0.0000	0.0000	0.0000	0.0955	0.0000	0.0156	0.0000	0.0348	0.0000
CQ4	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2819	0.0000	0.4111	0.0000	0.0000
Q2O	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.2866	0.0000	0.0000	0.0000	0.0000
N2	0.0611	2.3004	0.0290	0.0479	0.0000	0.2689	50.8006	0.0000	36.3389	0.8803	57.8929
O2	0.0000	0.0044	0.0017	0.0000	0.0000	0.0007	0.0508	0.0000	0.2546	0.0443	0.0576
Other											
New Liters:											
H	25.6	11.2	7.8	5.1	0.1	0.0	0.6	0.0	1.0	35.2	5.1
D	8.1	25.5	28.5	30.5	0.5	0.1	4.5	1.0	6.4	19.2	3.3
T (Decayed)	3.3	0.1	1.7	2.1	32.5	0.4	0.6	36.0	9.3	2.2	1.5
He-3 (Decayed)	1.2	0.1	0.8	1.7	12.9	47.7	1.9	14.1	5.6	0.2	1.4
He-4	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.1	0.0	0.2	0.0
CQ4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.6	0.0	0.0
Q2O	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
N2	0.0	1.8	0.0	0.0	0.0	0.2	40.7	0.0	29.1	0.7	46.4
O2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0
Other	0.0	0.1	0.0	0.0	0.0	0.1	0.3	0.0	0.1	0.0	0.0
Sum	38.3	38.8	38.9	39.4	46.0	49.0	49.5	51.2	52.3	57.6	57.7

2.2.7 Attachment 7

PC's to be Added to Standard Volume Before Run Composition (Liters)

PC #	H	D	T	^{3}He	^{4}He	CQ_4	Q_2O	N_2	O_2	Other	Total	Total Imp.
531	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
731	11.58	18.04	0.10	0.42	0.12	0.00	0.00	7.40	0.00	0.20	37.85	7.40
532	11.18	25.55	0.05	0.11	0.02	0.00	0.00	1.84	0.00	0.06	38.81	1.85
606	0.01	0.08	0.67	0.29	0.12	0.00	0.00	0.03	0.00	0.00	1.20	0.03
616	0.51	0.73	0.09	0.05	0.00	0.00	0.00	0.25	0.00	0.00	1.63	0.25
546	0.19	0.12	2.28	1.02	0.00	0.00	0.00	0.48	0.10	0.00	4.21	0.58
581	3.59	1.88	1.55	0.83	0.01	0.00	0.00	0.00	0.00	0.00	7.86	0.00
1101	0.19	0.21	0.62	8.31	0.01	0.00	0.00	0.02	0.01	0.02	9.39	0.03
810	0.22	2.04	0.87	4.87	1.81	0.00	0.00	0.15	0.00	0.00	9.96	0.15
662	1.14	2.14	0.56	0.35	0.00	0.00	0.00	8.74	0.00	0.01	12.96	8.75
904	0.08	0.51	0.13	1.95	5.21	0.00	0.00	9.96	0.00	0.13	17.97	9.96
664	7.31	9.32	1.96	0.73	0.01	0.00	0.00	0.26	0.02	0.00	19.62	0.28
1050	3.51	11.10	7.49	0.52	0.11	0.04	0.21	0.16	0.00	0.18	23.32	0.41

PC's to be Added to Standard Volume Before Run Accumulaton (Liters)

Total	Impurities	T	Q	He	Tot. Ads.	PC #
0.00	0.00	0.00	0.00	0.00	0.00	531
37.85	7.60	0.10	29.71	0.54	37.31	731
76.67	9.51	0.15	66.49	0.67	76.00	532
77.86	9.53	0.83	67.25	1.08	76.79	606
79.50	9.79	0.91	68.58	1.13	78.37	616
83.70	10.37	3.19	71.18	2.15	81.55	546
91.56	10.37	4.74	78.19	2.99	88.57	581
100.95	10.42	5.36	79.21	11.32	89.63	1101
110.91	10.57	6.23	82.34	18.00	92.91	810
123.87	19.34	6.79	86.18	18.35	105.51	662
141.84	29.43	6.92	86.90	25.51	116.33	904
161.46	29.71	8.88	105.49	26.26	135.20	664
184.78	30.30	16.37	127.59	26.89	157.89	1050

PC's which May be Added Directly to Loop During Run
Composition (Liters)

PC #	H	D	T	^3He	^4He	CQ_4	Q_2O	N_2	O_2	Other	Total	Total Imp.
1056	0.04	0.19	0.15	5.24	0.00	0.00	0.00	21.49	0.00	0.05	27.17	21.50
847	0.01	0.01	18.32	5.52	0.00	0.00	0.00	0.00	0.00	0.00	23.86	0.00
648	2.35	1.87	0.84	0.71	0.00	0.00	0.00	18.62	0.00	0.00	24.39	18.62
567	23.40	2.75	0.16	0.01	0.03	0.00	0.00	0.06	0.00	0.00	26.43	0.07
1093	0.01	26.39	0.08	0.11	0.00	0.00	0.00	0.01	0.00	0.00	26.60	0.01
1132	9.48	0.24	0.20	0.04	0.74	0.00	0.00	15.98	0.00	0.00	26.68	15.98
831	2.77	1.95	0.84	3.31	15.08	0.00	0.00	2.08	0.00	1.55	27.57	2.08
572	11.15	15.93	3.81	1.48	0.00	0.00	0.00	0.10	0.00	0.00	32.47	0.10
554	1.81	23.80	1.30	4.98	0.57	0.00	0.00	0.04	0.00	0.02	32.53	0.05
541	0.85	1.76	29.04	1.73	0.17	0.00	0.00	0.00	0.00	0.00	33.56	0.00
857	11.09	17.75	3.74	1.36	0.00	0.00	0.00	0.16	0.03	0.00	34.13	0.19
784	0.12	0.36	24.59	10.66	0.00	0.00	0.00	0.43	0.09	0.02	36.26	0.51
769	25.63	8.14	3.32	1.18	0.01	0.00	0.00	0.05	0.00	0.00	38.32	0.05
1031	7.81	28.55	1.71	0.79	0.00	0.00	0.00	0.02	0.00	0.00	38.89	0.02
675	5.09	30.49	2.05	1.71	0.00	0.00	0.00	0.04	0.00	0.00	39.38	0.04
672	0.09	0.49	32.47	12.92	0.00	0.00	0.00	0.00	0.00	0.00	45.97	0.00
570	0.00	0.11	0.37	47.69	0.53	0.00	0.00	0.22	0.00	0.06	48.99	0.22
724	0.62	4.55	0.58	1.91	0.00	0.40	0.36	40.68	0.04	0.35	49.47	41.47
1061	0.03	0.98	36.00	14.13	0.09	0.00	0.00	0.00	0.00	0.00	51.23	0.00
1046	1.03	6.38	9.31	5.61	0.00	0.58	0.00	29.10	0.18	0.07	52.26	29.85
995	35.17	19.15	2.20	0.18	0.20	0.00	0.00	0.70	0.03	0.01	57.64	0.74
1100	5.09	3.29	1.53	1.35	0.00	0.00	0.00	46.36	0.04	0.02	57.69	46.40

PC's which May be Added Directly to Loop During Run Accumulation (Liters)

Total	Impurities	T	Q	He	Tot. Ads.	PC #
211.95	51.84	16.52	127.97	32.13	179.82	1056
235.81	51.84	34.84	146.31	37.65	198.15	847
260.20	70.46	35.68	151.37	38.36	221.84	648
286.63	70.53	35.84	177.69	38.41	248.22	567
313.23	70.54	35.92	204.17	38.52	274.71	1093
339.90	86.52	36.13	214.09	39.29	300.61	1132
367.48	90.15	36.96	219.64	57.69	309.79	831
399.95	90.25	40.77	250.53	59.17	340.78	572
432.47	90.32	42.06	277.43	64.72	367.75	554
466.03	90.32	71.11	309.09	66.62	399.41	541
500.16	90.51	74.85	341.68	67.98	432.19	857
536.43	91.04	99.44	366.75	78.63	457.79	784
574.75	91.09	102.76	403.84	79.82	494.93	769
613.63	91.11	104.47	441.91	80.61	533.02	1031
653.01	91.15	106.52	479.55	82.32	570.70	675
698.98	91.15	139.00	512.59	95.24	603.74	672
747.97	91.42	139.37	513.08	143.46	604.51	570
797.44	133.24	139.95	518.83	145.37	652.07	724
848.68	133.24	175.95	555.84	159.59	689.08	1061
900.93	163.17	185.27	572.57	165.20	735.73	1046
958.57	163.91	187.47	629.09	165.58	793.00	995
1016.26	210.33	189.00	639.00	166.93	849.33	1100

3. Brief Results and Discussions

3.1 General

This extended TSTA loop run was performed successfully for 25 days. During this run, the Isotope Separation System (ISS) was operated continuously and was controlled completelly. Many profile data of each 4 cryogenic distillation columns were measured by laser raman spectroscopy. The Fuel Cleanup System (FCU) and the JAERI Fuel Cleanup System (JFCU) were both operated for extended periods. A wide range of impurities were added to the TSTA loop and were removed successfully and completely by FCU and JFCU. The interfacing of the two fuel cleanup units to the ISS was demonstrated to be straightforward with each of the FCUs. TSTA loop cleaned up about 20 PCs, that contained mixtures of hydrogen isotopes and impurities, and separated tritium with high purity. Total (mean) hydrogen isotope composition during this run was about H : D : T = 1 : 7 : 2 with ~ 100 grams of tritium. All safety system such as Tritium Waste Treatment System (TWT) worked effectively, so all operation was carried out safely. No major tritium release through stack was measured from the TSTA fuel processing loop. (J.L. Anderson & T. Hayashi)

3.2 Isotope Separation System

Highlight

All four ISS columns were kept cold for 23 days. After filling hydrogen isotopes from the Uranium beds, loop flow was maintained for 22 days continuously.

Column profiles under various conditions were obtained by laser raman spectroscopy as follows:

Column I	4 profiles
Column H	2 profiles
Column D	1 profile
Column T	8 profiles

Dynamic response to changes in parameters were measured for Column T on 5 occasions. The response was followed about 2 hours. Several laser sequences of up to 5 hours were made to observe feed and product stability.

H2 was added at the rate of ca. 1-2 % of loop flow for 10 days. During that time H2 + HD containing < 4 Ci/m3 was discharged to TWT at an average rate of ca. 200 cm3/min.

12 grams of pure tritium extracted from the reboiler of Column T and the purity measured during the extraction process. Purity of the gas during withdrawal was better than 99.8 % T2, however, the material collected measured 0.22 % H and 0.45 % D due to insufficient flushing of interconnecting lines, pumps, etc.

Major advance was made in the recognition of improved operating conditions of the helium refrigerator, helium flows and column stability. Previously we had been operating the refrigerator at a rather low temperature (~15 K) with low helium gas flow. Minor perturbations in valve positions, expansion engine speed, etc. resulted in major perturbations to the ISS columns. The same enthalpy balance can be achieved by operating at higher refrigerator temperatures (~ 18 ~ 19 K) and higher helium flow rates. Under these latter conditions minor changes in one column do not drastically alter flows and heat balances in the other columns. Thus greatly enhanced ISS stability was realized.

The on-line laser raman spectrometer permitted rapid analysis of condenser and reboiler product streams so that when a serious column imbalance occurred, we were able to diagnose the situation to permit a more educated approach to recovery.

Problems

The normal feed tap to Column I plugged about midway through the run, and the lower feed tap was utilized. This was due to impurities being transferred from FCU.

For several days it was not possible to make laser raman measurements due to a high back pressure in the FCU manifold used for sample recycle. An small additional pump within the EXP-2 globe box should be installed to mitigate this situation.

The inability to measure liquid level in the Column D reboiler continues to interfere with efficient operation of that column.

The inability to adequately reduce the flow through several flow control valves interferes with best operation of the columns, especially Column T. This situation will be mitigated as soon as the new flow sensor/flow control valves are installed.

(R.H. Sherman)

3.3 Fuel Cleanup System

Summary

The most significant accomplishment with the FCU during Annex IV year 5 was the extended loop operation which took place in April-May, 1992. During this run the FCU main flow path molecular sieve beds (both MSB1 and MSB2) were used for about three weeks and the Neutral Beam Interface (NBI) MSB3 was used for the entire four weeks. The main flow path was used to remove both artificial impurities from a gas cylinder (N2/CH4) and "real" impurities in the form of very impure gas mixtures which had been stored for considerable time in tritium shipping containers (LP-50's). Tritium from impurities was recovered both by the FCU's regeneration train (catalytic oxidation / freezing water / magnesium reduction of water) and using the JFCU regeneration train (catalytic oxidation / freezing water / electrolysis of water).

Details of FCU Extended Run Activities

Week 1: MSB1 was preloaded with gas from LP-50's (impurities and hydrogen isotopes). MSB3 was preloaded with hydrogen isotopes. Once loop operations were started, 60 sccm of 90 % N2 + 10 % of CH4 was added to the loop and removed by MSB1. Later this impurities addition rate was increased to as high as 200 sccm. When MSB1 broke through, MSB2 was put on-line. Plugging of MSB1 was experienced during this week-this is discussed below. MSB1 was regenerated using CR1/DTOF to collect all tritium as water ice in the DTOF. MSB2 was filled with impurities from the aforementioned cylinder. When it broke through, MSB1 was put on-line and MSB2 was regenerated in the same way that MSB1 had been regenerated. Thereafter, the DTOF was regenerated to recover tritium from the water by passing it over a hot magnesium bed. MGB1 was exhausted and MGB2 was put on-line.

Week 2 : At the beginning of the week, main loop flow was switched from FCU to JFCU while NBI flow continued through FCU MSB3. At the end of the week main loop flow through MSB1 was resumed with no impurities addition.

Week 3 : LP-50's were added directly into main loop flow at rated ranging from 0.5 ~ 2 SLPM. The impurities from these LP-50's were collected on MSB1 and MSB2. Plugging of MSBF2 and MSB1 occurred during these operations-this is discussed below.

Week 4 : More LP-50's were added to the main loop flow. During shutdown, water from MSBF1 and MSBF2 was passed over a hot magnesium bed and recovered hydrogen isotopes were sent to JFCU. Thereafter, MSB1 and MSB2 were warmed and the impurities and hydrogen isotopes from these beds were sent to the JFCU.

Lessons Learned

No plugging of the ISS occurred because of impurities getting through MSB's and reaching the ISS. Plugging at the inlet of ISS column H occurred, but this was during an abnormal operation involving the preloading of an FCU MSB which caused reversed flow out of the column H inlet. The nature of this plug (it broke loose easily at low temperature) indicates that it was probably not caused by impurities coming from FCU. The second (and last) ISS plug occurred at the feed of column I and followed switching flow from one FCU MSB to another. The cause of this plug is not known, but the line behind the fresh MSB may not have be purged sufficiently prior to putting it on-line.

The CR2/DTOF regeneration went well with little tritium being lost to the TWT during this operation. There did appear to be some detectable tritium getting through the DTOF which had not been observed in the past. This may have been due to some insulation damage which had occurred on the DTOF during maintenance.

The DTOF/ MGB operation also went well. Little or no water passed through the MGB unconverted except when MGB1 broke through resulting in a dramatic rise in exit humidity. This was the first use of MGB's during a loop operation. They have proven to be very effective in recovering hydrogen isotopes from water, but, of course, produce tritiated waste.

The plugging problems referred to above were caused by 1) the use of "real" impurities which contain water and 2) changes in the way the MSBFs are operated. The MSBFs and the DTOF are identical. Heating tape had been added to the DTOF inlet and only a specific DTOF temperature is used to prevent plugging. This had never been needed for the MSBFs since they have not in the past encountered much water. MSBF2 (temperature controlled in a manner identical to the DTOF) plugging resulted from operating it with a setpoint which was too low and with no heater tape on its feed line. MSBF1 had been outfitted with a new temperature controller which uses a time proportioning algorithm to control coolant (LN2) flow rather than the simple, alarmed, on/off algorithm used for MSBF2 and the DTOF. Using previously established temperature setpoints, this new control scheme resulted in water passing through MSBF1 and plugging MSB1. Much lower temperature setpoints are required for MSBF1 to work effectively with its new controller.

Essentially all of the FCU problems encountered during this run resulted from MSBF problems. These freezers could be made to work properly, but it is likely not worth the effort. Ambient temperature molecular sieve beds have long been used in the TWT to collect water very effectively. Before the next loop run, at least one freezer should be replaced with an ambient molecular sieve bed for testing. (R.S. Willms)

3.4 JAERI Fuel Cleanup System

Summary

The first complete integrated loop run with the Isotope Separation System (ISS) with 4 columns and the JAERI Fuel Cleanup system (JFCU) after replacing Ceramic Electrolysis Cell (CEC) was performed successfully with a 100 grams of tritium. This test was performed as a part of a 25 day TSTA extended loop run (Apr. 20 -- May 14, 4 weeks). JFCU test with TSTA loop was conducted in the 2nd week and 4th week.

Fuel processing operation was performed with various impurities, adding a few % of impurities (10 % methane and N2 mixture), a regeneration & purging of molecular sieve beds (CMSB) of the TSTA fuel clean up system (TSTA-FCU), and gases processed by Mg bed from TSTA-FCU. During these fuel processing operations, "External" Cold Trap (CT) regeneration line was selected and " Internal " Catalytic Reactor (JCR1) dilution line was used. The stream to the Tritium Waste Treatment (TWT) system was at 6 ~ 7 Nl/min. Its tritium level was low enough except at the ISS-JFCU connection and at CTs (from CT1 to CT2) switching after increasing CT1's differential pressure (> 500 torr).

The interaction between the ISS and JFCU was investigated. Loop flow was processed continuously by the Palladium Diffuser (PD) and more than 5 Nl/min of hydrogen isotopes stream was produced for feed to ISS continuously. Loop flow and ISS columns pressure were varied, however, no major operational trouble occurred if ISS column I pressure was controlled below 1000 torr.

CEC decomposed water well (max : ~ 12 A = 1.1 mol/hr). The increase of CEC current limit setting (from 10 A to 15 A) was helpful for CEC performance and control. Replaced orifice, installed at the evacuation valve of CEC O2 jacket, worked well and CEC differential pressure control was easier. After the completion of this run, a large internal leak of CEC tubes was found. Next generation cell will solve this R&D problem.

Small humidity spike at the outlet of CTs was detected again when each CT was changed (once per an hour). However, it was at an acceptable level and no problem for loop operation, even if humidity level was very high at the inlet of the CTs.

Zirconium Cobalt Bed No.2&3 (ZCB2&3) still did not work for the processing of JFCU-GC (Gas Chromatograph) gas even though the regeneration of ZCB2&3 was carried out before this loop run. Some tritium was exhausted through ZCB2&3 during GC analysis. More high temp. regeneration/activation treatment with hydrogen is needed.

At the shut down of loop operation, almost all residual gas, except ISS, and purge gas were received and processed by JFCU and about 220 Nl of total hydrogen isotope gases in the TSTA loop (include ~ 22 grams of tritium) was recovered in the ZCB1 of JFCU.

Through these operations, JFCU worked quite well as well as TSTA-FCU and all operators / staff gained much experience. In a second half of this extended loop run, JFCU and TSTA FCU were used. Comparing the TSTA-FCU, the JFCU advantage of continuous tritium recovery from impurities was demonstrated. If the processing fuel does not include a considerable amount of He and impurities, however, TSTA-FCU system will be easier to operate.

More detail results of the J-FCU performance were summarized in the different paper. (T. Hayashi)

3.5 JAERI Vacuum Pump

Almost all installation work of this pump was carried out, but not completed before this extended loop run. Therefore, we could not operate this pump during this run. The evacuation performance test of JVAC was carried out after this extended loop run by the stand-alone situation and this JVAC test in the loop will be planed in the next TSTA loop operation. (T. Hayashi)

4. Conclusion

A extended TSTA loop run was carried out with 100 grams of tritium for 25 days from April 20 through May 14, 1992. One of the major purposes of this run was to demonstrate stable control and safe operation of the entire TSTA with the J-FCU. This run was a most important milestone under the Annex IV during the original five years collaboration between U.S.-DOE and JAERI.

Through this extended run, many technical highlight were obtained as follows:

1) The full four columns ISS was operated continuously and was controlled completelly without any major trouble.

2) Many profiles and dynamics data of each cryogenic distillation columns of the ISS were measured by laser raman spectroscopy.

3) The TSTA-FCU and the J-FCU were both operated for extended periods. A wide range of impurities were added to the TSTA loop and were removed successfully and completely by FCU and JFCU.

4) The interfacing of the two fuel cleanup units to the ISS was demonstrated to be straightforward with each of the FCUs without any significant trouble.

5) Hot magnesium beds in the TSTA-FCU and ceramic electrolysis cells in the J-FCU worked effectively to decompose tritiated water.

6) During this run, TSTA loop cleaned up about 20 PCs, that contained mixtures of hydrogen isotopes and impurities. Finally, about 12 grams of pure tritium (> 99.7 %) was extracted from the bottom of the column T to a PC.

7) All safety system such as TWT worked effectively, so all operation was carried out safely. No major tritium release through stack was measured from the TSTA fuel processing loop.

References

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