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AEROJET-GENERAL NUCLEONICS INDUSTRIAL REACTOR (AGNIR)

OPERATING PROCEDURES

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OPERATING PROCEDURES

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AGNIR OPERATING PROCEDURES

I. INTRODUCTION

The procedures to be followed for normal startup, shutdown and emergency conditions are delineated below. The critical experiments, power calibration, technical specifications and the hazard report appear in separate documents to allow revision of each document with relative ease as the reactor equipment and procedures are changed.

The reactor is operated from the control console on which are located the switches for the control rod drive mechanisms, the annunciator panel, strip chart recorder and nuclear instrument read-out meters for the startup, intermediate and power channels.

Procedures required for normal, safe operation are detailed in the following section. These procedures include: reactor startup, continuous operation; and routine reactor shutdown and emergency reactor shutdown conditions. To compile daily and extended reactor operating information, check lists will be used for routine reactor operation. The list of operating rules presented below will be posed in the AGNIR control room.

II. OPERATING RULES

A. At least two people must be in the reactor building during reactor operation, at least one of which is a reactor operator. Operation of the reactor shall only be performed by licensed operators except as provided in 10 CFR 55.9.

B. A senior licensed operator shall be present in the reactor building or readily available on call at all times during its operation, and shall be present in the reactor building during initial startup and approach to power, recovery from an unplanned or unscheduled shutdown or significant reduction in power, and refueling, or as otherwise prescribed in the reactor facility license.

C. Reactor sequences, interlocks, and safety circuits are to remain operative at all times except as designated below.

D. All reactor check lists and log books are to be kept up-to-date.

E. A minimum of two nuclear safety channels are to be on-the-line at all reactor power levels.

F. Any maintenance performed on the AGNIR system shall be done with at least 3 of the 4 nuclear safety channels energized. All maintenance must be authorized in writing by reactor supervisor.

G. When the reactor control room is to be unattended (see A above), or at the end of a working day, the reactor control key is to be removed from the console and secured in the facilities locked master file. All other facility keys, when not in use, are also to be secured in the master file.

III. REACTOR STARTUP PROCEDURES

Prior to initiating any reactor startup procedures, the reactor operator reads and initials any additions to the Operators Information Log in which the reactor supervisor transcribes any special instructions, changes in modes of operation or special reactor conditions that have been made. By initialing these comments, the reactor operator acknowledges that he has read and understands these additions. No reactor operator may manipulate the reactor controls until he has signed the Operators Information Log, any questions being directed to the reactor supervisor, prior to signing the Log.

As part of the first reactor startup of the day, instruments and auxiliary equipment must be placed in operation, calibrated and checked for operability. The following step-by-step procedures fulfill the requirements for safe startup of the AGNIR system. Reference is made to Figure 1, the AGNIR Startup Checklist.

A. REACTOR CONTROL AND ANNUNCIATOR SYSTEMS

The following must be performed before initiating instrument calibration:

1. Turn the console key switch ON.
2. Verify that the safety rod and rod drives are at the down limit. Record indicated safety rod position. Verify that magnet is contacting the safety rod and current is applied to the magnet.
3. Repeat Step 2 for shim and regulating rod.
4. Scan annunciator panel and correct any conditions that will result in a reactor scram. Record and explain any annunciator conditions that are not correctable.

B. INSTRUMENT CALIBRATION

Check all nuclear instrumentation for operability. The correct indications and/or limit settings are checked for the following instruments:

1. Water radioactivity monitor is checked by placing a calibrated source of known activity at the detector and insuring that an alarm is actuated.
2. Channel 1, Log Count Rate Calibration: 10^2 and 10^6 cpm.
3. Channel 1, period calibration: depress calibrated trip circuit check button until trip is annunciated.
4. Channel 1, source level indications: check and record neutron counting rate with all control rods inserted. Remove source from core and observe decrease in neutron counting rate. Replace source in core.
5. Channel 2, Log N calibration: 10^{-5}, 10^{-11} amps.
6. Channel 2, period calibration: depress calibrated trip circuit check button until trip is annunciated.
7. Channel 3, level trip: depress calibrated trip circuit check button until trip is annunciated. Check zero.
8. Channel 4, level trip: depress calibrated trip circuit check button until trip is annunciated. Check zero.

FIGURE 1

AGNIR DAILY STARTUP CHECK LIST

Initial Each Section as Completed

DATE _____

1. Reactor Control and Annunciator Systems

   a. ☐ Console key switch ON
   b. ☐ All control rods on down limit
   c. ☐ Magnet current applied and magnets contacting control rods
   d. ☐ Record and explain any annunciator lights

   _____

   _____ _____

2. Instrument Calibration

   a. ☐ Check water radioactivity monitor alarm with source
   b. ☐ Check Channel 1 log count rate calibration
   c. ☐ Check Channel 1 period calibration and trip circuit
   d. Record Channel 1 count rate with all rods inserted _____
   e. ☐ Remove source from core and observe decrease in counting rate.
      ☐ Replace source in core.
   f. ☐ Check Channel 2 log neutron calibration
   g. ☐ Check Channel 2 period calibration and trip circuit
   h. ☐ Check Channel 3 zero and trip circuit
   i. ☐ Check Channel 4 zero and trip circuit
   j. Check all 4 channel detector voltages and record

      (1) _____ (3) _____

      (2) _____ (4) _____

   k. Reduce detector voltage on all 4 channels and record voltage where low voltage trip occurs. Reset voltages.

      (1) _____ (3) _____

      (2) _____ (4) _____

   l. Check and record compensating voltage on Channel 3 _____
   m. ☐ Notify the Health Physicist

      _____

3. Scram Check

   a. Manual Scram
      1) ☐ Raise safety rod approximately 1 inch
      2) ☐ Depress scram button
      3) ☐ Observe audible annunciation, depress Horn Acknowledge
      4) ☐ Observe return of rod and drive to lower limit. Reset annunciator.
   b. Reactor Period Scram (Channels 1 and 2)
      1) ☐ Initiate period scram
      2) ☐ Observe correct annunciation, depress Horn Acknowledge
      3) ☐ Reset Annunciator
   c. High Nuclear Flux Scram (Channels 3 and 4)
      1) ☐ Initiate high level scram
      2) ☐ Observe correct annunciation, depress Horn Acknowledge
      3) ☐ Reset annunciator

4. Startup Channel Operational Check

   a. Recheck Channel 1 count rate and record _____ _____

5. Water Condition

   a. Observe and record pool water conductivity _____
   b. Observe and record pool water temperature _____
   c. Observe and record pool water radioactivity _____ _____

6. Check List Verification

   a. Comments _____

      _____

      _____

   b. Operator's Signature _____

   c. Senior Operator's Approval Signature _____

9. Detector voltage check: sequentially reduce the detector voltage on Channels 2, 3 and 4 and record voltage at which trip is annunciated.

10. Check and record compensating voltage applied to the compensated neutron ion chamber on Channel 3.

C. SCRAM CHECK

1. Manual Scram

   a. Raise safety rod approximately 1 inch.

   b. Initiate manual scram, (depress manual scram button).

   c. Verify that annunciator indication is correct; depress Horn Acknowledge.

   d. Check safety rod to be sure both rod and drive have returned to lower limit. Reset annunciator.

2. Reactor Period Scram (Channels 1 and 2)

   a. Initiate period scram.

   b. Verify that annunciator indication is correct; depress Horn Acknowledge.

   c. Reset annunciator.

3. High Nuclear Flux Scram (Channels 3 and 4)

   a. Initiate high level scram.

   b. Verify that annunciator indication is correct; depress Horn Acknowledge.

   c. Reset annunciator.

D. STARTUP CHANNEL OPERATIONAL CHECK

Observe and record count rate on Channel 1.

E. WATER CONDUCTIVITY

a. Observe and record pool water conductivity.

b. Observe and record pool water temperature.

F. CHECK LIST VERIFICATION

When all the above pre-startup checks and calibrations have been satisfactorily completed, the operator verifies that the reactor is ready for operation. Appropriate space is also provided on the startup check list for comments. When a senior operator has approved the startup check list, the reactor is ready for startup operations.

Table 1 lists the procedures for periodic scram and interlock checks and maintenance. A Maintenance Log is maintained in the reactor control room. Maintenance on the reactor is performed only upon the written request of the reactor supervisor. Person performing maintenance enters into the log book the maintenance performed, date, and any comments regarding the condition of the part or component checked, lubricated, etc., and signs his name. In addition, the reactor supervisor is notified in writing that the maintenance has been completed along with any special comments.

IV. APPROACH TO CRITICAL AND CONTINUOUS POWER OPERATION PROCEDURES

A. APPROACH TO POWER PROCEDURES

The reactor is brought to operating power by withdrawing the safety rod to the upper limit. This allows the shim and regulating rod to be moved by activating a safety interlock. The regulating rod is then withdrawn one-half its travel distance. The reactor at this point in the procedure should still be subcritical. Criticality is achieved by withdrawing the shim rod until a stable, positive reactor period is achieved. For power levels below approximately 1 kw, no further rod movement is required except an insertion of either or both the shim and control rod to establish an infinite reactor period as the desired power level is approached. For power levels in excess of a few kilowatts, further withdrawal of the shim or regulating rod may be required to maintain a stable positive period due to the negative reactivity coefficient of the TRIGA fuel. For power levels in excess of 1 kilowatt, the Am-Be neutron source must be removed as part of the procedures in approaching power. The

TABLE 1

QUARTERLY MAINTENANCE CHECK LIST

Mechanism	Checkout Procedure
Earthquake Scram	Reference procedure "Manual Scram." To initiate scram, simulate earthquake scram by manually actuating tripping mechanism, continue with manual scram procedures.
Low Water Flow Alarm	To initiate alarm, turn off circulation pump. Observe audible annunciation, depress Horn Acknowledge. Restart circulating pump, observing normal condition when reset button is depressed.
Accidental Criticality Alarm	Maintained and tested by Health and Safety personnel.
Crane Bridge Location Alarm	To initiate alarm, move crane off stop. Observe audible annunciation, depress Horn Acknowledge. Move crane to stop, observing normal condition when reset button is depressed.
Control Rod Drives	Measure control element drive withdrawal rate, magnet release time, element insertion time. Check and adjust, if necessary, control element interlocks and position readouts.
Water Temperature Scram	Temperature switch will be removed from water loop and placed in a calibrated oven to check scram point.
Water Level Alarm	Depress float.

procedures to be used in this operation are described below. For reactor operation below 1 kw, no movement of the source is required.

During startup, the reactor power and period measuring instruments must be watched closely. Reactor periods in the range of 10 to 30 seconds are convenient for normal reactor operation. Channel 3 is a linear power channel covering a wide range of power, the pico ammeter must be switched many times as the reactor power increases, maintaining the pico ammeter on scale, preventing high nuclear flux scram. Channel 4 is set on the maximum power range in which the reactor will be operating and provides a high-flux nuclear safety channel.

The step-by-step procedures used to bring the AGNIR to operating power are as follows:

1. Scan annunciator panel to determine that all interlocks and scram conditions have been reset.
2. Set linear power Channel 3 on the lowest range.
3. Place strip chart recorder selector switch on Channel 1.
4. Place linear power Channel 4 on the power range to be used during the reactor power run.
5. Determine whether source removal will be required. (Removal required above power levels of 1 kw.)
6. Begin safety-rod withdrawal. When the safety rod is fully withdrawn, check the subcritical multiplication rate of Channel 1 with previous reactor startup.
7. Withdraw regulating rod approximately half way; the reactor should still be subcritical.
8. Switch strip chart recorder selector switch to Channel 2.
9. Withdraw shim rod until a stable positive reactor period between 10 and 30 seconds is obtained. If power level will be below 1 kw, allow power to rise exponentially until desired power is achieved. If a power level above 1 kw is to

be achieved during the run, raise power level to about 1 watt; level reactor power and remove neutron source and place in storage rack and proceed with approach to power. When operating power is approached, the shim and regulating rods may be adjusted to establish an infinite reactor period.

10. Once a stable reactor power has been established, the strip chart recorder may be switched to Channels 3 or 4 to aid in establishing a constant reactor power. Once this has been established, the recorder can be switched to the expanded scale on Channel 4 to monitor minor fluctuations in the power level, if desired.

B. CONTINUOUS POWER LEVEL OPERATION PROCEDURES

During reactor operation, a log sheet is used to record pertinent operating data. The AGNIR log sheet is shown in Figure 2. Space is provided on the log sheet to record the following startup and initial criticality data.

1. Date and time of run
2. Purpose of run
3. Maximum power to be achieved during the run
4. Channel 1 and 2 reading with reactor shut down
5. Channels 1 and 2 readings with safety rod withdrawn
6. Time critical reached
7. Initial position of all control rods at power
8. Reactor shutdown time, scram type and scram cause

At regular intervals pertinent reactor data are recorded in the interim entries space. These entires include:

1. Time and reactor power level
2. Channels 2, 3 and 4 readings
3. Pool water temperature
4. Control rod positions

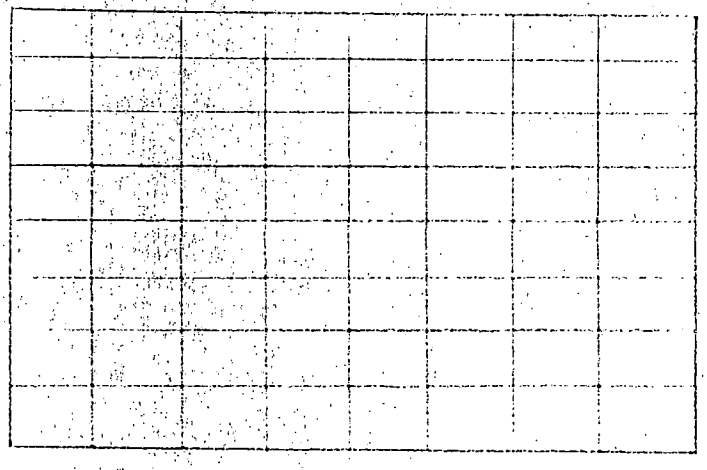
FIGURE 2

AGNIR LOG SHEET

DATE _____ TIME _____

1. Purpose of run _____
2. Record water temperature _____
3. Maximum power to be achieved during the run _____
4. Channels 1 and 2 readings shutdown, all rods in (1)_____ (2) _____
5. Channels 1 and 2 readings safety rod out (1)_____ (2) _____
6. Time critical reached _____
7. Control rod position at critical SH _____ REG _____
8. Time source removed. (Required only for operation above 1 kw.) ____
9. Time steady state power level reached _____
10. Initial control rod position at power SH _____ REG _____
11. Shutdown time _____
12. Scram type _____
13. Scram cause _____
14. Interim entries

    a. Time of entry
    b. Power level
    c. Channel 2
    d. Channel 3
    e. Channel 4
    f. Water temperature
    g. Shim rod position
    h. Regulating rod position



15. Record kilowatt-hours of operation during this run _____
16. Record accumulated kilowatt-hours of operation _____
17. Comments _____

The above interim entries are made at one hour intervals or immediately following any reactor power level change. At the completion of a power run, the neutron source is replaced in the reactor core and the number of kilowatt hours of operation is determined and accumulated. Appropriate space is provided for comments on reactor operation.

V. NORMAL REACTOR SHUTDOWN PROCEDURES

At the end of a normal operation period, the reactor is shut down by manually inserting the control rods.

A. SHUTDOWN CHECK LIST

The AGNIR Shutdown Check List, Figure 3, requires the operator's initials indicating that each shutdown check has been satisfactorily completed, namely:

1. Date and time.
2. Check that all nuclear channels are approaching normal shutdown levels.
3. All control rods and rod drives are at lower limit.
4. Record water conductivity, temperature and radioactivity.
5. Neutron source replaced in reactor core.
6. The console key switch is turned to the OFF position, the key removed and secured.

At the end of the shutdown check list the operator's initials appear, indicating satisfactory completion of the check list. The check list must be approved by a senior operator at the end of a day's operation. Sufficient space is available for applicable comments concerning the reactor shutdown procedures.

FIGURE 3

AGNIR DAILY SHUTDOWN CHECK LIST

1. Date and Time _____ _____
2. Nuclear channels approaching shutdown level _____
3. All control rods and drives are at lower limit _____
4. Console key switch OFF _____
5. Record water conductivity _____, temperature _____ and radioactivity _____
6. Neutron source returned to core position _____
7. Console key removed and secured _____
8. Comments _____

   _____

   _____
9. Operator's signature _____
10. Senior Operator's signature _____

VI. EMERGENCY REACTOR SHUTDOWN PROCEDURES

A. PROCEDURES

In the event of any abnormal reactor condition not covered by the automatic scram system, the reactor is shut down by depressing the MANUAL SCRAM button.

1. Any of the following conditions will automatically scram the reactor:
   a. Short reactor period, less than 4 ± 1 seconds
   b. High reactor power, 110% of power (275 kw)
   c. Low reactor power, ($<$ 2% of full scale on Channel 3)
   d. Seismic shock (Modified Mercalli IV)
   e. Loss of pool water (1 ft or more below floor level)
   f. Low nuclear instrument detector voltage (510 ± 10 volts, Channels 2, 3 and 4)
   g. Loss of nuclear instrument power
   h. Loss of magnet power
   i. Bulk pool water temperature above $125 \pm 5^{\circ}F$
2. If an automatic scram occurs, proceed as follows:
   a. Note scram cause and take appropriate action immediately.
   b. Depress Horn Acknowledge button to shut off alarm.
   c. Verify that the control rods are at the down limit and rod drive mechanisms are returning to the down limit.
   d. Correct difficulty which caused scram. If cause of scram is not immediately obvious, check all scram circuits.
   e. Depress RESET button.
   f. If annunciator panel is cleared, the reactor may be started up again, with the presence of a senior operator.

B. OPERATING LIMITS

Reactor operation procedures presented in previous sections involve routine startup, operation and shutdown conditions. Any operation or series of events which exceed the foregoing operational limits will require reporting the incident to the reactor supervisor and cessation of normal operation. A resume of abnormal conditions and critera required for reporting such conditions is shown in Figure 4, the AGNIR Conditions Requiring Report. All nuclear accidents associated with the facility will be classified as Class I, II or III emergencies. The AGNIR accident classification description is presented below.

C. CLASSIFICATION OF RADIOLOGICAL EMERGENCIES

1. Definitions

a. Class I

An emergency of a localized nature, but of such magnitude as to require cessation of normal operation of the facility. The situation can be controlled by personnel assigned to the facility with possible assistance from established emergency units.

b. Class II

An emergency of such magnitude and extent as to require evacuation of the immediate vicinity of the hazardous area and to be a possible threat to other facilities in the immediate area. Control of the situation requires active assistance of established emergency units.

c. Class III

An emergency of such magnitude and extent that other facilities and areas are definitely affected and

FIGURE 4

AGNIR CONDITIONS REQUIRING REPORT

Condition	Normal Operation	Report	Shutdown for Review	Accident Conditions
Reactor Period	$>$10 seconds	$<$4 seconds	$<$1 second	Fuel cladding stretching $\leq$ 0.35 seconds
Reactor Power	250 kw	$>$ 260 kw	$>$275 kw	Phase change of fuel occurs at $\sim$550°C, 1 Mw
Pool Water Temperature	$<$ 110°F	$>$120°F	$>$130°F	Damage to resin bed possible above 120°F, damage to ion chambers above 150°F

major emergency procedures are involved. Control of the situation requires full activation of established emergency units.

2. Determination

a. Responsibility

Health and Safety - The Health Physicist assigned to the AGNIR facility is responsible for over-all assessment of the radiological hazard.

Senior Operator - The Health Physicist is responsible for initial assessment of the radiological hazard. If the Health Physicist is not immediately available, the Senior Operator will be responsible for the initial radiological hazard assessment. The class determination may then be revised, following more extensive survey by the Health Physicist.

b. Class I Determination

A Class I emergency is one in which the radiological hazard is confined to the immediate vicinity. Guide lines for determining Class I emergency conditions are as follows:

- Widespread but low-level surface contamination
- Rupture of the pool vessel (activity of coolant $<$ RCG) (Radioactivity Concentration Guide as defined in the Federal Radiation Council Report No. 1)
- Rupture of an in-reactor experiment (no release of circulating fluids)

c. Class II Determination

A Class II emergency is one which requires evacuation of the facility and which may also endanger other facilities in the area. Determination of such an emergency is, therefore, based on indications that air contamination may be released to the surrounding

area and/or on the magnitude of direct radiation levels. Control requires active assistance from established emergency units. Conditions which may indicate a Class II emergency are as follows:

- Rupture of the pool vessel (activity of coolant > RCG)
- Rupture of a fuel element
- Rupture of in-reactor experiment (release of circulating fluids to coolant water)

d. Class III Determination

The determination of a Class III emergency is primarily based upon the direct release of air contamination to the surrounding area or on nuclear radiation of such a magnitude that other facilities will be directly affected. Control of the situation requires full assistance from established emergency units.

e. Emergency Class Upgrading

An initial declaration may be upgraded from Class I or II if the appropriate authority has reason to believe that conditions warrant such upgrading.

D. NOTIFICATION SYSTEM FOR EMERGENCIES

In the event of an emergency, the Senior Operator will immediately:

1. Execute promptly all appropriate actions to maximize personnel safety.
2. Notify the following organizations:

- Class I: Notify the Radiological Safety Officer.
- Class II or Class III: Activate the AGN Emergency Plan by dialing 333 (Emergency Communication System). The Radiological Safety Officer will be automatically alerted.

NOTE: If the evacuation alarm is activated (switch or monitor) the Central Guard Post Plant Protection Officer will activate the Emergency Communication System by dialing 333. The Radiological Safety Officer, Plant Control, Medical and Maintenance are all connected to the Emergency Communication System.

E. RADIOLOGICAL EMERGENCY PROCEDURES

1. Hazard Assessment

The true magnitude of a potential or existing radioactivity hazard will not usually be immediately apparent. A thorough radiation survey of the area will be initiated as soon as possible, under the direction of Operating and Health Physics personnel to enable a more accurate evaluation of the emergency. Such surveys will be conducted utilizing the protective and dosimetric devices specified by the Health Physicist. The class determination will be made according to the criteria discussed above.

2. Plan of Action for AGNIR Operating Personnel - Emergency at the AGNIR Facility

a. Class I

- Execute promptly all appropriate actions to maximize personnel safety.
- If reactor is operating:
  - * Scram reactor manually
  - * Remove console operation key
  - * Clear affected area and keep it clear
- If reactor is not operating:
  - * Remove console operation key
  - * Clear affected area and keep it clear

- Notify Radiological Safety Officer, determine the extent and degree of contamination. Initiate, if necessary and feasible, contamination control measures to confine the radioactivity within the smallest possible area. A radiation and contamination survey will be made around the affected area. Sealing materials, such as masking tape, will be used as necessary to assist in the confinement.
- Initiate corrective action.
- Written records will be kept throughout the action provided such records can be kept without, in any way, affecting the safety of the personnel involved or the restoration of normal operations.

b. Class II

- Execute promptly all appropriate actions to maximize personnel safety.
- Scram reactor manually and/or remove console key; trip emergency switches at door.
- Notify Central Guard Post Plant Protection Officer.
- Evacuate all personnel except the Senior Operator and the Health Physicist, using prescribed evacuation routes. The Health Physicist and the Senior Operator will remain in the area to assist in emergency procedures, to set up temporary access controls, and to initiate appropriate remedial measures.
- Re-entry of the AGNIR facility for inspection of the area will be done by Health Physicists. Portable survey instruments will be utilized during re-entry and personnel protective equipment as required.
- If, upon re-entry, no unusual activity is detected, the Health Physicists will notify Industrial Security that the area may be re-occupied.

- If, upon re-entry, activity is detected, access to the area will remain restricted. Operating personnel may assist the Health Physicist in actions deemed appropriate to effect a reduction of the hazard and subsequent downgrading of the emergency.
- Written records will be kept throughout the action provided such records can be kept without, in any way, affecting the safety of the personnel involved or the restoration of normal operations.

c. Class III

- Execute promptly all appropriate actions to maximize personnel safety.
- Scram the reactor and/or remove the console key, trip emergency switches at door.
- Notify Central Guard Post Plant Protection Officer.
- Evacuate all personnel, using prescribed evacuation routes.
- Health Physicists re-entering the facility shall be equipped with full protective clothing and fresh air breathing apparatus. High range survey instruments will be utilized during re-entry.
- Once the extent of radiation and contamination has been determined by the Health Physicist, operating personnel may assist the Health Physicist in determining remedial measures to be undertaken and in the execution of such measures.
- Complete written records will be kept throughout the action provided such records can be kept without, in any way, affecting the safety of the personnel involved.

See Note on Record Sheet!

LEGEND

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