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Title: Instrumentation Set Points

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1.0 Introduction

The mission of the National Criticality Experiments Research Center (NCERC) at the Device Assembly Facility (DAF) is to conduct experiments on critical assemblies with fissile material at or near criticality in order to explore reactivity phenomena and to operate the assemblies in the region from subcritical through delayed critical to beyond prompt critical. The critical assemblies contain fissile and other materials that are used to carry out research and development activities in support of criticality safety, accident simulation and analysis, weapons and reactor design, and other programmatic needs. There are four critical assemblies at the NCERC; Comet, Flat-Top, Godiva, and Planet. There are two Safety Significant systems, the SCRAM Safety System (SSS) and the Nuclear Instrumentation (NI) system, that are integral programmatic systems for safe operations at the NCERC.

System Design Descriptions (SDDs) have been developed for the four critical assembly machines as well as for the SSS (this SDD also includes information pertaining to the Operational Interlock System (OIS)) and NI system. The Forward section of the six NCERC SDDs state that the SDDs have been developed in accordance with DOE-STD-3024-2011. Appendix E, Section 4.1.6.4, *Setpoints and Ranges*, of DOE-STD-3024-2011 states the following:

This section of the SDD should identify setpoints associated with the system (including pre-trip alarms) and the purpose of the setpoints. The values of setpoints and other system limitations should be correlated with the system requirements, especially TSR-required setpoints.
Note: A common practice is including setpoints and limitations information in a set of tables in a stand-alone document that contains such information for numerous systems. ...
Not repeating setpoint data in the SDD may be advantageous in order to avoid the need to revise the SDD each time a setpoint specification is changed. When complete setpoint data is not provided as part of the SDD, provide a reference to the governing setpoint information.

This document provides all of the NCERC critical assembly machines' set points and basis for these set points, as the DOE standard suggests.

2.0 Acronyms

DAF	Device Assembly Facility
DOE	Department of Energy
HEU	High Enriched Uranium
NCERC	National Criticality Experiments Research Center
NI	Nuclear Instrumentation
OIS	Operational Interlock System
PLC	Programmable Logic Controller
psig	Pounds per Square Inch Gauge
SDD	System Design Description

SSS	SCRAM Safety System
TSR	Technical Safety Requirement

3.0 COMET Critical Assembly Machine

Comet is a general-purpose, vertical assembly table. Coarse assembly is achieved by the stroke of two hydraulic rams with fine assembly made by means of a ballslide driven by a computer-controlled stepper motor. Disassembly, hence shutdown, is achieved by gravity which forces the hydraulic ram table to descend. The hydraulic cylinders are connected to the pump package via flexible hoses. The pressure output of the hydraulic pump is variable, and can be adjusted for any load capacity between 0 and approximately 2,000 psi. The pump package has two compressed air filled accumulators. The accumulators are normally charged to about 200 psig and have two functions. The primary function is to provide surge suppression to the hydraulic system when valves are switched. The second function is to assist gravity in lowering the ram table and its experimental load in a loss of power situation (i.e., hydraulic pump no longer provides system pressure to drive the rams down).

The only set points associated with Comet are the two pressure switches for the accumulators. These accumulator pressure switches are Barksdale model TC9612-0 and they are located on the pump package for Comet (located about three feet away from the Comet structure). The set points for these accumulator pressure switches are set at or above 50 psig. The accumulator pressure switches provide a signal to the PLC. If either accumulator pressure is less than its set point, a software interlock is not met and Comet will auto-runout if it is operating or it cannot be reset if it is not operating. These accumulator pressure switches are not safety related. The set point for these accumulator pressure switches is based on over fifty years of operational experience with Comet.

4.0 FLAT-TOP Critical Assembly Machine

The Flat-Top critical assembly provides benchmark neutronic measurements in spherical geometry, with a number of different fissile driver materials. The Flat-Top assembly has interchangeable spherical cores of highly enriched uranium (HEU) or plutonium (Pu) metal surrounded (during operation) by a reflector of thick natural uranium. The reflector is subdivided into a stationary reflector, into which the core is recessed, and two movable quadrants mounted on keyed tracks. The stationary hemisphere contains voids for control rods. The hydraulic system provides the motive force to position the quarter-sphere reflector segments for critical operations and shutdown including SCRAM. The SCRAM system initiates a decrease in power within one second of receiving a SCRAM signal or on a loss of power. The Safety Blocks are located at their most reactive position when fully inserted and, therefore, Safety Block retraction results in only removal of reactivity from the system.

There are four pressure-actuated switches, two pneumatic and two hydraulic, that ensure adequate system pressures. For each block, one pressure switch is mounted on the gas side of each accumulator and one pressure switch is mounted on the fluid side between the accumulator and the check valve. The gas side pressure switches, PSL-3 and PSL-4, are Barksdale Model TC9612-1 rated for 3000 psig. The switches are adjustable over a range of 35 psig – 340 psig decreasing and 40 psig – 400 psig increasing. The set point for the gas pressure switches is 150 psig – 180 psig. These switches monitor the gas side pressure and will not allow a system reset, or will initiate an automatic system runout if the pressure is below the set point.

The hydraulic side pressure switch on the A-Block is a dual set point switch that provides two functions (PSL-1 and PSH-1). It monitors for low hydraulic pressure on the A-block hydraulic circuit just as the B-Block switch does. However, this is a dual switch which also monitors the output from the hydraulic pump unit for a high pressure condition. If a high pressure or low pressure is encountered, the PLC will initiate an automatic system runout and not allow a system reset. This switch is a Barksdale Model TC9622-2 rated for 3000 psig. The switch set points are adjustable over a range of 125 psig – 1360 psig decreasing and 135 psig – 1500 psig increasing. The set point for the A Block low hydraulic pressure switch is 150 psig – 200 psig. The set point for the Flat-Top high hydraulic pressure switch is 700 psig – 800 psig.

The hydraulic side pressure switch, PSL-2, on the B-Block is a Barksdale Model TC9612-2 rated for 3000 psig. The switch is adjustable over a range of 125 psig – 1360 psig decreasing and 135 psig – 1500 psig increasing. The set point for the B Block hydraulic pressure switch is 150 psig – 200 psig. This switch monitors the hydraulic pressure in the B-Block hydraulic circuit and will not allow a system reset, or will initiate an automatic system runout if the pressure is below the set point.

All four of the pressure switches on Flat-Top are Safety Significant and the accumulators are filled using a calibrated pneumatic gauge. The basis for the values assigned for these set points is operational experience. Originally the low pressure set point was higher, but it has been reduced so that it would not trip during the decrease in pressure when the safety blocks start to move. It has been verified many times that 150 psig is sufficient to remove the safety blocks.

5.0 GODIVA Critical Assembly Machine

The Godiva critical assembly is designed as a burst assembly that can be operated in a steady state mode or operated to produce a super-prompt critical nuclear excursion for benchmarking analysis of models. The Burst Rod Drive System includes a pneumatic cylinder, air on-off valve, directional flow valve, burst rod limit switches, and burst rod shaft. An air pressure switch is mounted downstream of the air supply to monitor burst rod air pressure availability. The Godiva machine controller monitors the state of the air pressure switch, and the controller will not allow Godiva burst rod to operate when system air pressure drops below 50 psig. A pressure regulator with a local indicator gauge is installed downstream of the pressure switch to regulate pressure to the burst rod (nominally at 30–40 psig). The air pressure switch set point is the only set point for the Godiva critical assembly and it is not associated with a safety system or safety feature. The purpose of the set point is to ensure there is enough pressure for the pressure regulator to supply 30-40 psig, which was identified experimentally to provide the desired burst rod travel time of 60-90 milliseconds.

6.0 PLANET Critical Assembly Machine

Planet is a general-purpose, vertical assembly machine capable of supporting a wide range of experiments on a smaller scale than Comet. Planet was originally built as a duplicate for Comet when demand for the machines resulted in programmatic conflicts, particularly in the area of criticality safety training. There are no set points for the Planet critical assembly machine.

7.0 SCRAM Safety System

For both buildings containing critical assemblies, there is an ODD and EVEN SSS PLC. Each PLC monitors every manual SCRAM button, every door interlock, and two of the four Logarithmic-

Neutron (Log-N) Nuclear Instrumentation (NI) systems for that building. If either the ODD or EVEN PLC detects an off-normal condition, that PLC will cause both machines in that building to SCRAM. There are no set points associated with the SCRAM Safety System.

8.0 Nuclear Instrumentation System

All operations of critical assemblies require that the relative change in the neutron population be monitored. The NI System is used locally to determine assembly building entry requirements, configure machines, and perform hand stacking operations. The NI System is used remotely during approach to critical, low power, and burst operations. A pre-start checklist is used to verify the performance of the Log-N, Linear Channel, and Startup Detection systems prior to operating the critical assembly. During critical operations, the Log-N System serves as the primary reactor protection system and provides a SCRAM signal if the neutron population exceeds a preset level. This is the only set point associated with the NI System and is normally set at one order of magnitude higher than the expected neutron level (between 10^{-3} and 10^{-11} amps) for any particular experiment, which is specified in the experiment plan.

9.0 Summary

Table 9.1 – Summary of System Setpoints

Component	Component ID	System	Set Point	Purpose
Comet Accumulator Pressure Switches	PSL-003, PSL-004	Comet Hydraulic System	≥ 50 psig	To trigger an auto-runout and not allow the system to reset if low accumulator pressure is detected
Flat-Top Accumulator Pressure Switches	FT-PSL-003, FT-PSL-004	Flat-Top Hydraulic System	150-180 psig	To trigger an auto-runout and not allow the system to reset if low accumulator pressure is detected
Flat-top A-Block Hydraulic High/Low Pressure Switch	FT-PSL-001	Flat-Top Hydraulic System	700-800 psig high pressure 150-200 psig low pressure	To trigger an auto-runout and not allow the system to reset if low or high hydraulic pressure is detected
Flat-Top B-Block Hydraulic Low Pressure Switch	FT-PSL-002	Flat-Top Hydraulic System	150-200 psig	To trigger an auto-runout and not allow the system to reset if low hydraulic pressure is detected
Godiva Burst Rod Pressure Switch	G-PSL-001	Godiva Pneumatic System	50 psig	To not allow the Godiva burst rod to operate if low pressure is detected
Log-Ns	LOG-11 LOG-12 LOG-13 LOG-14 LOG-21 LOG-22 LOG-23 LOG-24	Nuclear Instrumentation System	10^{-3}–10^{-11} amps	Provide a SCRAM signal if the neutron population exceeds a preset level.

10.0 References

1. CEF-ENG-SDD-0346, *Comet Critical Assembly System Design Description*, Martin Parrales, Rev. 5, January 30, 2014.

2. CEF-ENG-SDD-0347, *Planet General Purpose Critical Assembly System Design Description*, Martin Parrales, Rev. 9, January 30, 2014.

3. CEF-ENG-SDD-0348, *Godiva Critical Assembly System Design Description*, Martin Parrales, Rev. 6, January 30, 2014.

4. CEF-ENG-SDD-0349, *Flat-Top Critical Assembly System Design Description*, Martin Parrales, Rev. 7, January 30, 2014.

5. CEF-ENG-SDD-0350, *NCERC Nuclear Instrumentation System Design Description*, Martin Parrales, Rev. 6, January 30, 2014.

6. CEF-ENG-SDD-0351, *System Design Description for the NCERC SCRAM and Operational Interlock System*, Martin Parrales, Rev. 5, January 30, 2014.