General Electric Advanced Technology Manual

Chapter 1.1

Operational Summary

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1.1 OPERATIONAL SUMMARY (Plant Startup)

Learning Objective:

1. Arrange the following events for a plant startup to rated power in the correct sequence:

    a. prestartup check sheet
    b. authorization for startup
    c. withdrawal of SRMs
    d. realignment of head vent
    e. withdrawal of IRMs
    f. reset HPCI and RCIC isolation
    g. SJAE's steam supply shifted to main steam
    h. mode switch transferred to run position
    i. RWM automatically bypassed
    j. synchronize generator to grid
    k. RBM placed in service
    l. oxygen concentration less than 4%

1.1.1 Introduction

Before cold startup, prestartup check lists are completed on all systems required to support startup and power operation. Included in these checks are the following: operational checks on safety related systems to ensure their availability; nuclear steam supply and balance of plant system valve and switch lineups from control room panels; and functional checks of systems such as the Neutron Monitoring Systems (NMS) and Reactor Manual Control System (RMCS). The shutdown cooling mode of the Residual Heat Removal (RHR) System is secured and the recirculation pumps are started and powered by the low frequency motor generator sets. The Recirculation Flow Control (RFC) System is in individual loop manual control. The Condensate and Feedwater System is prepared to supply water to the reactor vessel. This includes bringing chemistry into specification by recirculating water from the condenser hotwell through the condensate demineralizers and feedwater heaters. A vacuum is drawn in the main condenser to aid in the removal of noncondensible gases from the reactor vessel and main steam lines.

1.1.2 Approach to Critical and Pressurization of the Reactor

Following the completion of the prestartup checks, authorization for startup must be received from the station management. The reactor mode switch is placed in the "STARTUP" position and control rods are withdrawn, using the Rod Manual Control

System, according to the specified sequence. When a control rod has been withdrawn to the full out position, a coupling check is made by attempting to further withdraw the rod. If the control rod blade is uncoupled from the control rod drive, a rod overtravel alarm is received and corrective measures must be taken. Control rod withdrawal continues until criticality is achieved. The time, rod position, reactor period, and reactor water temperature are then recorded. After neutron flux measurement overlap with the Intermediate Range Monitor System detectors has been demonstrated, the Source Range Monitor (SRM) System detectors are withdrawn as required to maintain the count rate between 10^2 and 10^5 counts per second (cps).

After the reactor is critical, a reactor period of 75 to 100 seconds is established to raise power to the heating range. The IRMs are ranged upward as required to maintain proper on scale readings. Reactor power increase continues until heating power is reached, upper range 6 to lower range 7 of IRMs. At this point, control rod withdrawal is governed procedurally at the heatup rate limit of approximately 90^0F/hr. The Technical Specification limit is 100^0F/hr.

As reactor water temperature increases, the coolant expands which causes reactor vessel level to increase. The Reactor Water Cleanup System is aligned to reject water to the main condenser or to the Liquid Radwaste System to maintain normal reactor vessel water level. It is usually more desirable to reject the excess water to the condenser in order to minimize the water processing load on the Liquid Radwaste System. This evolution continues until rated temperature and pressure are reached.

As temperature increases from 200^0F to 212^0F, the reactor vessel head vent alignment to the equipment drain sump is secured and realigned to the main steam line.

Between 5 and 120 psig, reactor steam dome pressure, the low reactor pressure isolation of Reactor Core Isolation Cooling (RCIC) and High Pressure Coolant Injection (HPCI) systems are reset and placed in standby configuration. Surveillance for RCIC and HPCI are performed following bypass valve (BPV) opening at approximately 140 psig. Warming of the RFPs, main turbine and the Offgas System is started.

As pressure approaches 140 psig, the Electro Hydraulic Control (EHC) System pressure regulators would start to open bypass valve number 1. Following RCIC and HPCI surveillance, the pressure setpoint is increased to maintain 50 to 75 psig above reactor pressure until pressure is at 920 psig.

Between 300 and 500 psig the Steam Jet Air Ejectors (SJAEs) are shifted from auxiliary steam supply to reactor steam. At about 350 psig, a reactor feed pump is started and placed in service.

As pressure reaches 920 psig, the bypass valves begin to open to control reactor pressure at the EHC System pressure setpoint. Control rods are withdrawn to increase power, which results in further opening of the bypass valves. When power reaches about 5%, the reactor mode switch is shifted to the "RUN" mode, and the IRMs are fully withdrawn. Control rods are withdrawn until $1^1/_2$ BPVs are open, representing sufficient steam flow to roll the main turbine and provide minimum loading following synchronization to the grid.

At about this time, the Feedwater Control System (FWCS) is placed in automatic and RWCU System reject flow is discontinued.

1.1.3 Startup and Synchronization of the Generator

A turbine acceleration rate is chosen depending upon various turbine temperatures and the turbine is rolled to synchronous speed. The generator is then synchronized to the transmission system through the generator output breakers. The operator increases load on the generator by using the load selector to open the control valves. Opening of the control valves causes the bypass valves to automatically close to regulate reactor pressure.

Once all bypass valves are closed, any further increase of the load selector results in a setpoint adjustment only so the load selector is raised to the expected power level.

1.1.4 Increase of Power to Rated

Further increase in generator load is accomplished by increasing reactor power by rod withdraw and recirculation flow changes. As reactor power and pressure rises, steam throttle pressure increases which causes the EHC System to open the control valves further, thus increasing turbine and hence generator power.

Control rods are further withdrawn to increase power to 20%. At this power the second condensate and condensate booster pumps are placed in service. Additional demineralizers are placed in service as needed. The second reactor feed pump is rolled and maintained at minimum speed until needed. Feedwater control is transferred from single element to three element control.

When power exceeds 20%, the Rod Worth Minimizer (RWM) is automatically bypassed. At 25% power, thermal limits per Technical Specifications are maintained. At 30% power, the Rod Block Monitor (RBM) is activated. When reactor power reaches 40% the RFPs are balanced.

Control rods are withdrawn to just below the 80% rod line to prevent entering the instability region. Reactor power is further increased using the recirculation system until flow is greater than 35 Mlbm/hr. Control rods are then withdrawn to establish the 100% control rod pattern. When reactor recirculation pump speed is at or greater than 45%, the Recirculation Flow Control (RFC) system is placed in Master Manual. Core flow is increased until 100% (2436 MWth) power *or* 100% flow is obtained.

Twenty four hours after reaching 15% reactor power, the Primary Containment oxygen concentration must be less than or equal to 4%.

1.1.5 Startup Sequence

1. Functional and/or precritical checks have been completed and the following systems are in operation:
   a. Recirculation System
   b. Control Rod Drive Hydraulic System
   c. Closed Cooling System
   d. Circulating Water System
   e. Service Water System
   f. Condensate and condensate booster pump on long cycle
   g. RWCU System
   h. Main Steam Isolation Valves are open
   i. Moderator temperature 100^{o}F
   j. All NMS are operable
   k. RMCS operable
   l. Steam to the Turbine Sealing Steam System
   m. Containment Systems

2. Obtain the rod withdrawal sequence from nuclear engineer and get the shift engineer's approval for startup.

3. The reactor is taken critical by control rod withdrawal. Record the following:
   a. Time
   b. Rod/Gang position and number
   c. Period
   d. Reactor water temperature

4. Establish a 75-100 second period. Avoid a period shorter than 50 seconds.
   a. If period is <35 seconds, insert control rods until the reactor is subcritical and contact the nuclear and shift engineers
   b. Reactor periods <5 seconds are report-able to NRC within 24 hours.

5. Change IRM range switches to maintain between 25-75 on the 0-125 scale.

6. Keep SRM power level between 10^2 and 10^5 by withdrawing the detectors. Do not withdraw detectors to <100 cps until all IRM's are on range 3 or above. The SRM detectors may be fully withdrawn after reaching IRM range #8 and must be fully withdrawn prior to going into the run mode.

7. Raise power level by control rod withdrawal until the desired heatup rate is reached.

8. During heatup and cooldown, the following parameters shall be recorded every 15 minutes until 3 successive readings at one point are within 5 ^{0}F:
   a. Steam dome pressure (converted to temperature)
   b. Reactor bottom head drain temperature
   c. Recirc. loop A and B temperatures

9. At a reactor temperature of 190^{0}F
   a. Shut reactor head vent to drywell.
   b. Open reactor head vent to main steam line.

10. Reject water as required from the RWCU System to the main condenser to maintain a normal reactor water level.

11. At > 100 psig, start warming steam lines to RFPs and SJAEs. Reset RCIC and HPCI low pressure isolation and start warming its steam line.

12. At 150 psig, the Electro Hydraulic Control System (EHC) will start to open BPV #1.

13. Avoid bypassing steam by raising the pressure set point to 920 psig. At rated steam flow, this will result in a turbine throttle pressure of 950 psig and a reactor pressure of ~1005 psig.

14. At 400 psig, the SJAEs, preheaters and gland seal steam can be switched from auxiliary steam to reactor steam. Place a RFP in operation.

15. At 920 psig, the EHC system will start to open BPVs.

16. The reactor mode switch can be transferred to "RUN" after ensuring that the following
   a. ARPMs are reading > 5% and < 12%.
   b. MSIVs are open
   c. Condenser vacuum > 23" Hg.
   d. Reactor pressure >850psig and low reactor pressure alarms are clear.

17. Transfer the recorder switches to the APRM and withdraw the IRM detectors.

18. Continue to pull control rods until $1^1/_2$ BPV’s are open to the condenser. Discontinue rejecting water from the cleanup system when the steaming rate exceeds CRD Hydraulic System makeup. Place the STARTUP LEVEL CONTROLLER in AUTO. Roll the main turbine. Synchronize the generator to the grid and apply initial load.

19. Withdraw control rods and increase power to ~20%. Place the second condensate pump, condensate booster pump, and additional condensate demineralizer units in service as power increases.

20. At 40% power place the second RFP in service.

21. Continue rod withdrawals in combination with flow changes as recommended by the nuclear engineer until the desired power level is reached.