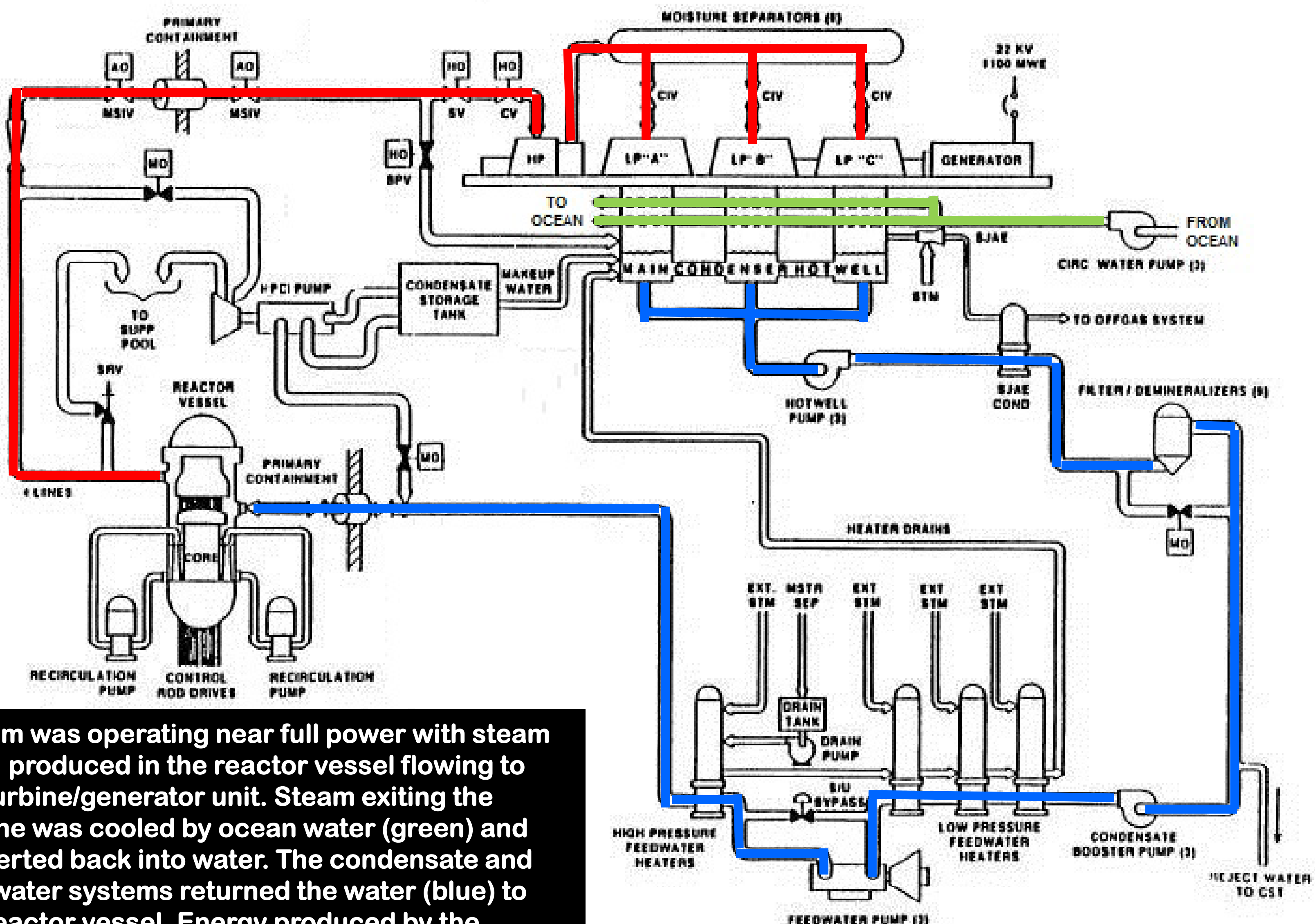
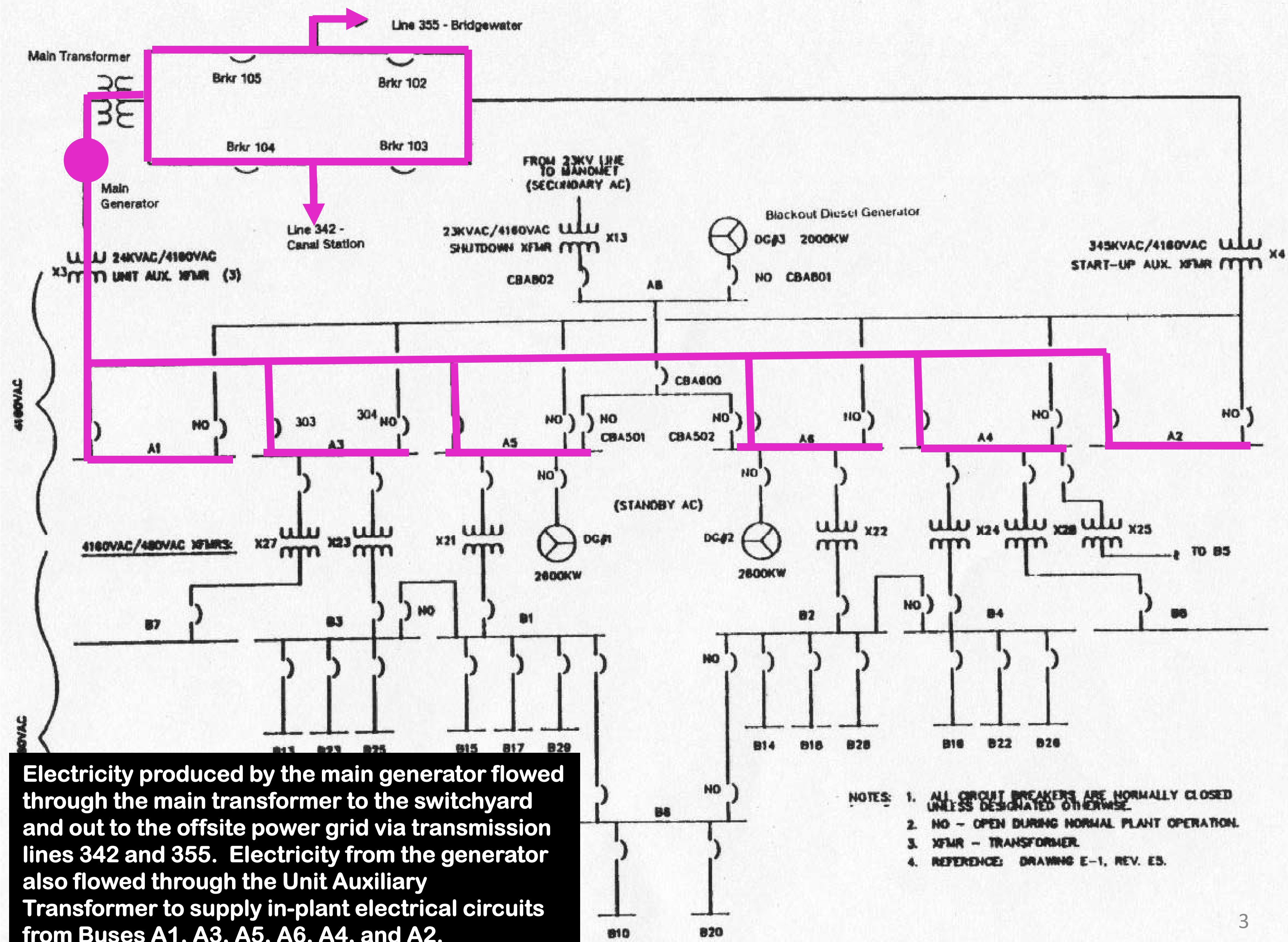
UCS Backgrounder on Pilgrim's January 27, 2015 Event

Source: NRC Flickr Gallery, Courtesy Entergy Nuclear

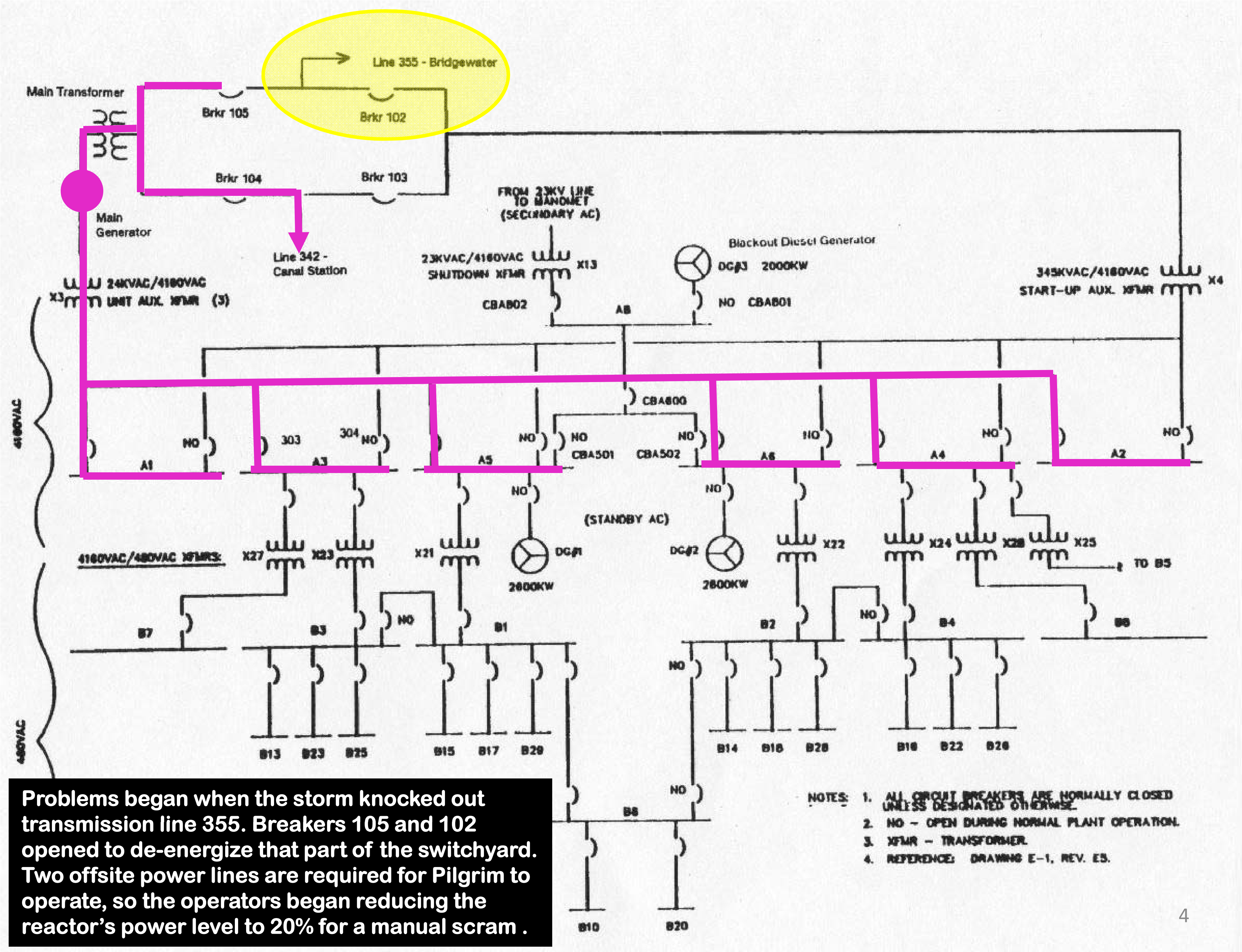
February 3, 2015



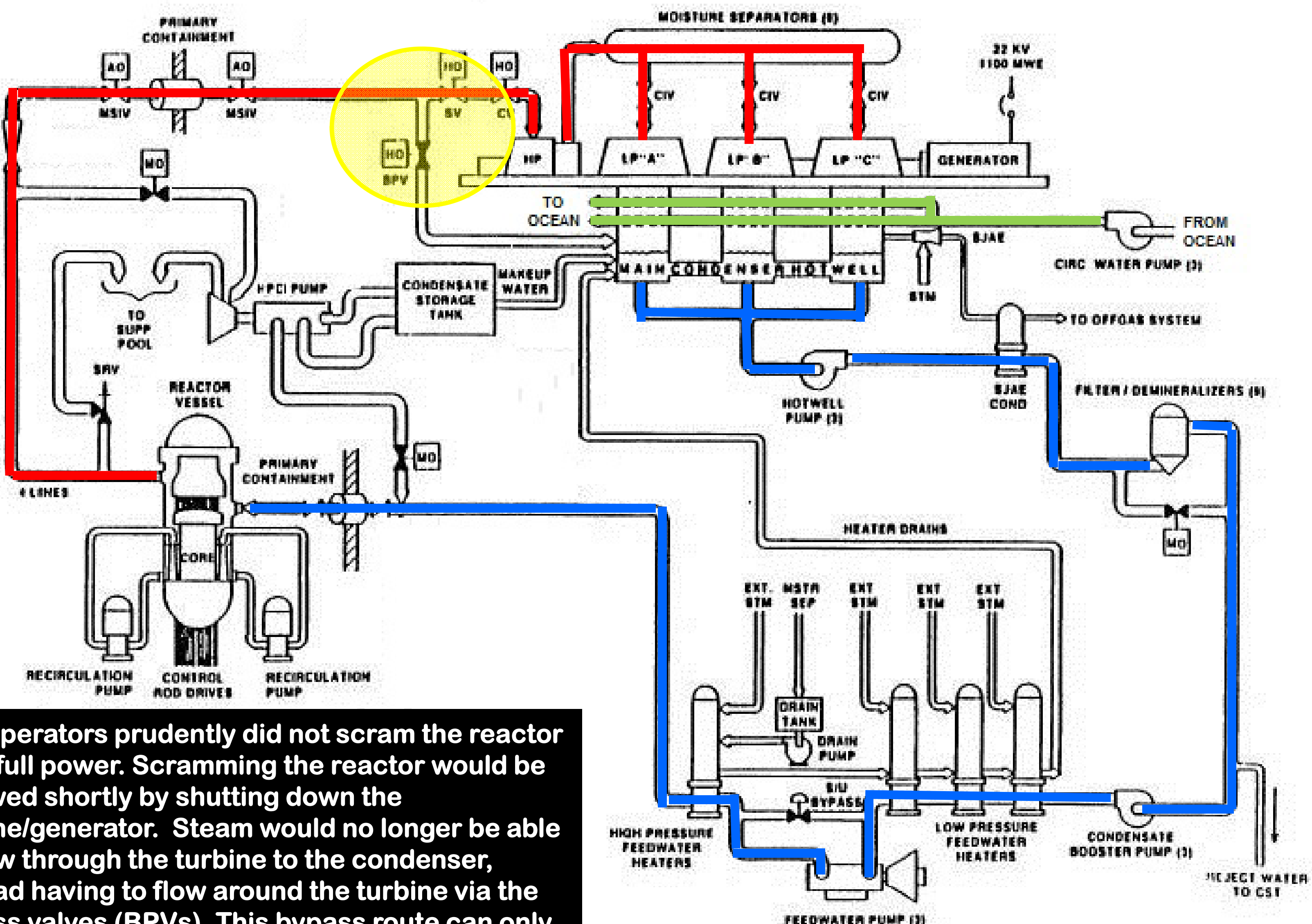
Pilgrim was operating near full power with steam (red) produced in the reactor vessel flowing to the turbine/generator unit. Steam exiting the turbine was cooled by ocean water (green) and converted back into water. The condensate and feedwater systems returned the water (blue) to the reactor vessel. Energy produced by the reactor core was balanced by heat dissipated to the environment. Mass leaving the reactor vessel as steam was matched by the makeup water.



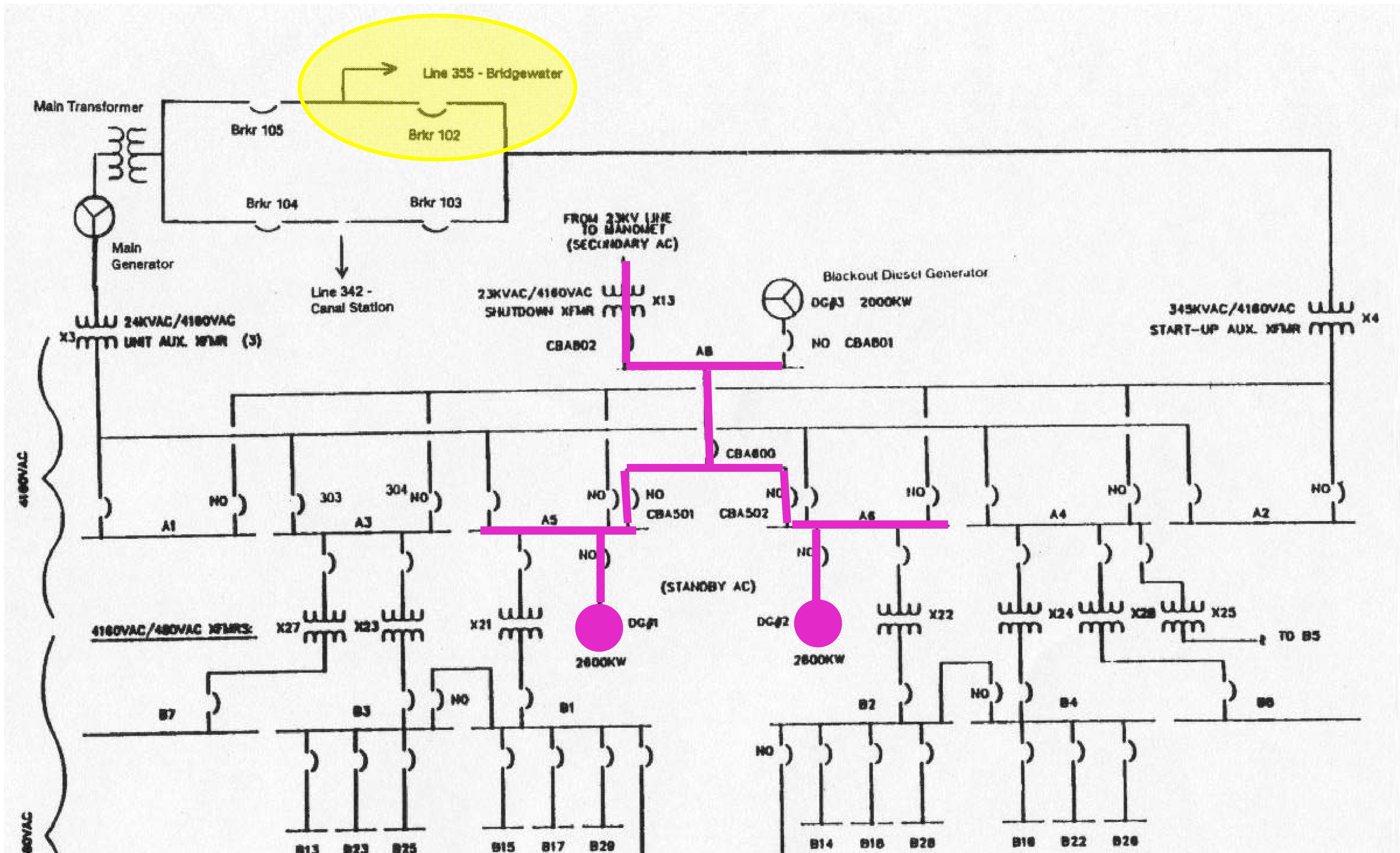
Electricity produced by the main generator flowed through the main transformer to the switchyard and out to the offsite power grid via transmission lines 342 and 355. Electricity from the generator also flowed through the Unit Auxiliary Transformer to supply in-plant electrical circuits from Buses A1, A3, A5, A6, A4, and A2.



Problems began when the storm knocked out transmission line 355. Breakers 105 and 102 opened to de-energize that part of the switchyard. Two offsite power lines are required for Pilgrim to operate, so the operators began reducing the reactor's power level to 20% for a manual scram .

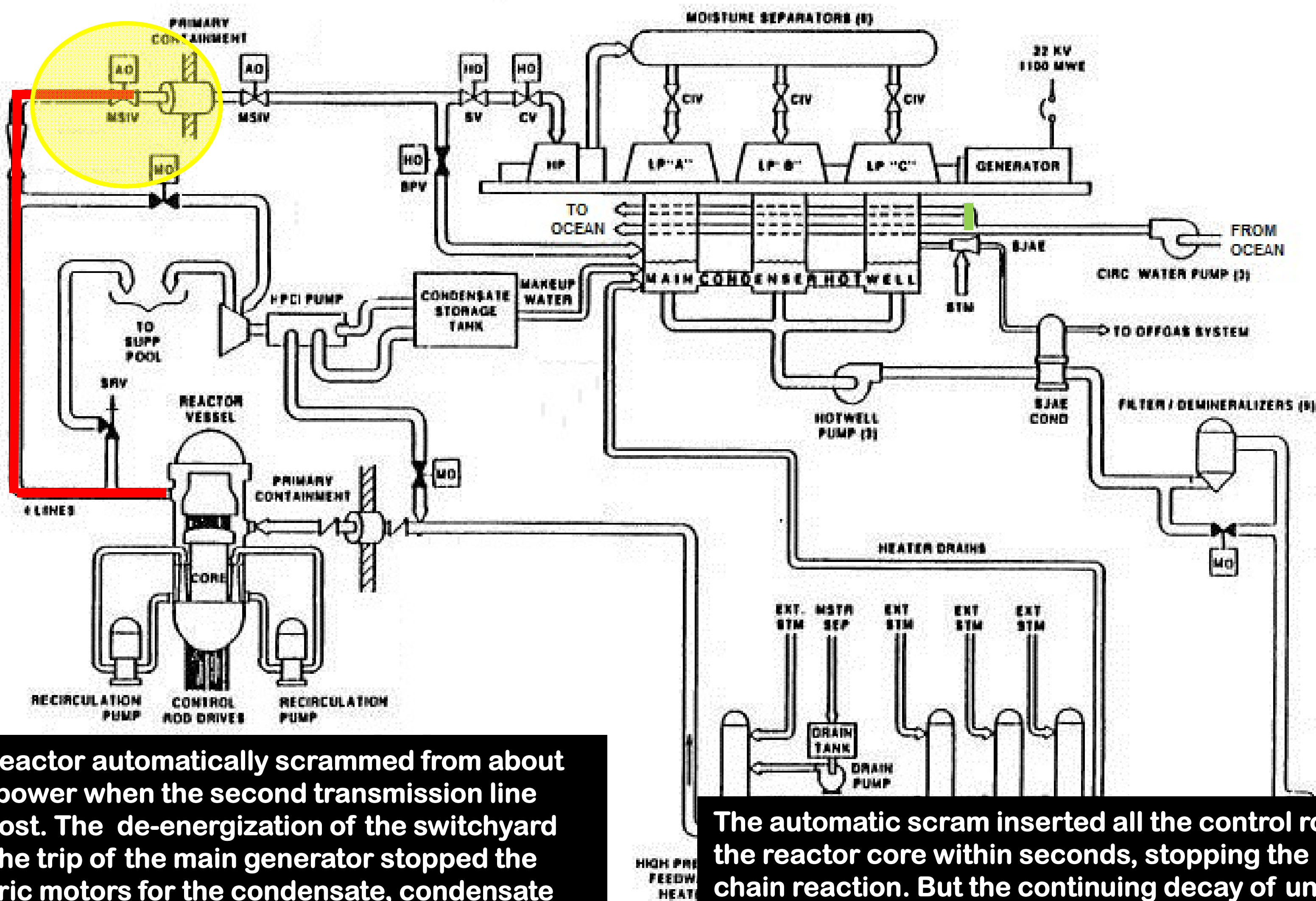


The operators prudently did not scram the reactor from full power. Scramming the reactor would be followed shortly by shutting down the turbine/generator. Steam would no longer be able to flow through the turbine to the condenser, instead having to flow around the turbine via the bypass valves (BPVs). This bypass route can only handle up to about 30% of rated steam flow. Scramming the reactor from 20% power would be within the capacity of the BPVs.



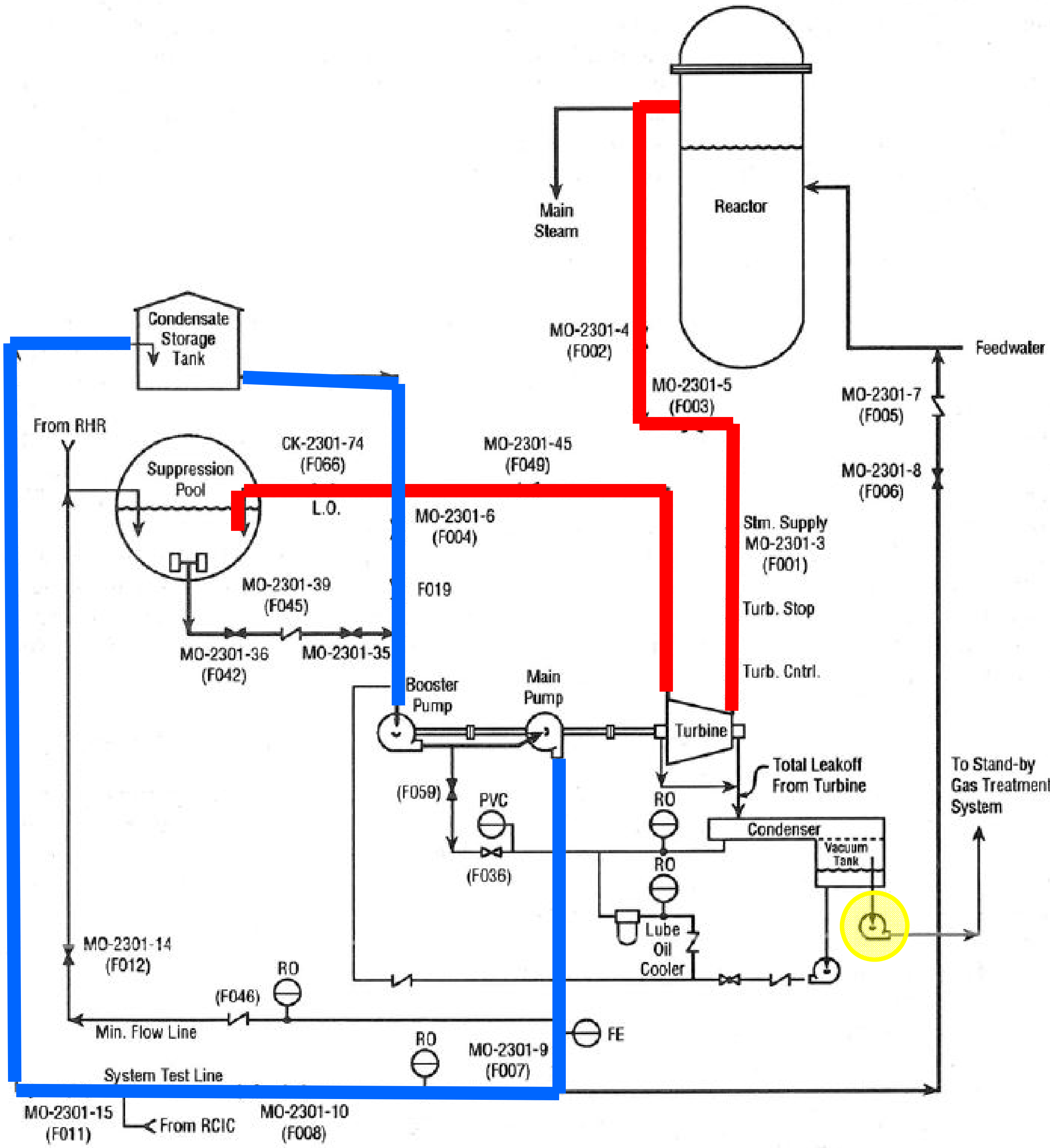
Problems deepened when the storm knocked out transmission line 342. Breakers 104 and 103 opened to de-energize the entire switchyard. Both emergency diesel generators started and re-powered Buses A5 and A6. The 23,000 volt transmission line remained able to supply electricity to these buses via the Shutdown Transformer.

Buses A1, A3, A4, and A2 were not getting electricity. The components powered from these electric circuits stopped running. The majority of the plant's components could no longer be used.



The reactor automatically scrammed from about 52% power when the second transmission line was lost. The de-energization of the switchyard and the trip of the main generator stopped the electric motors for the condensate, condensate booster , and circulating water pumps. The power loss also caused the main steam isolation valves to close, blocking the steam flow path to the main condenser.

The automatic scram inserted all the control rods into the reactor core within seconds, stopping the nuclear chain reaction. But the continuing decay of unstable byproducts of past fissions generated considerable heat which in turn produced steam.



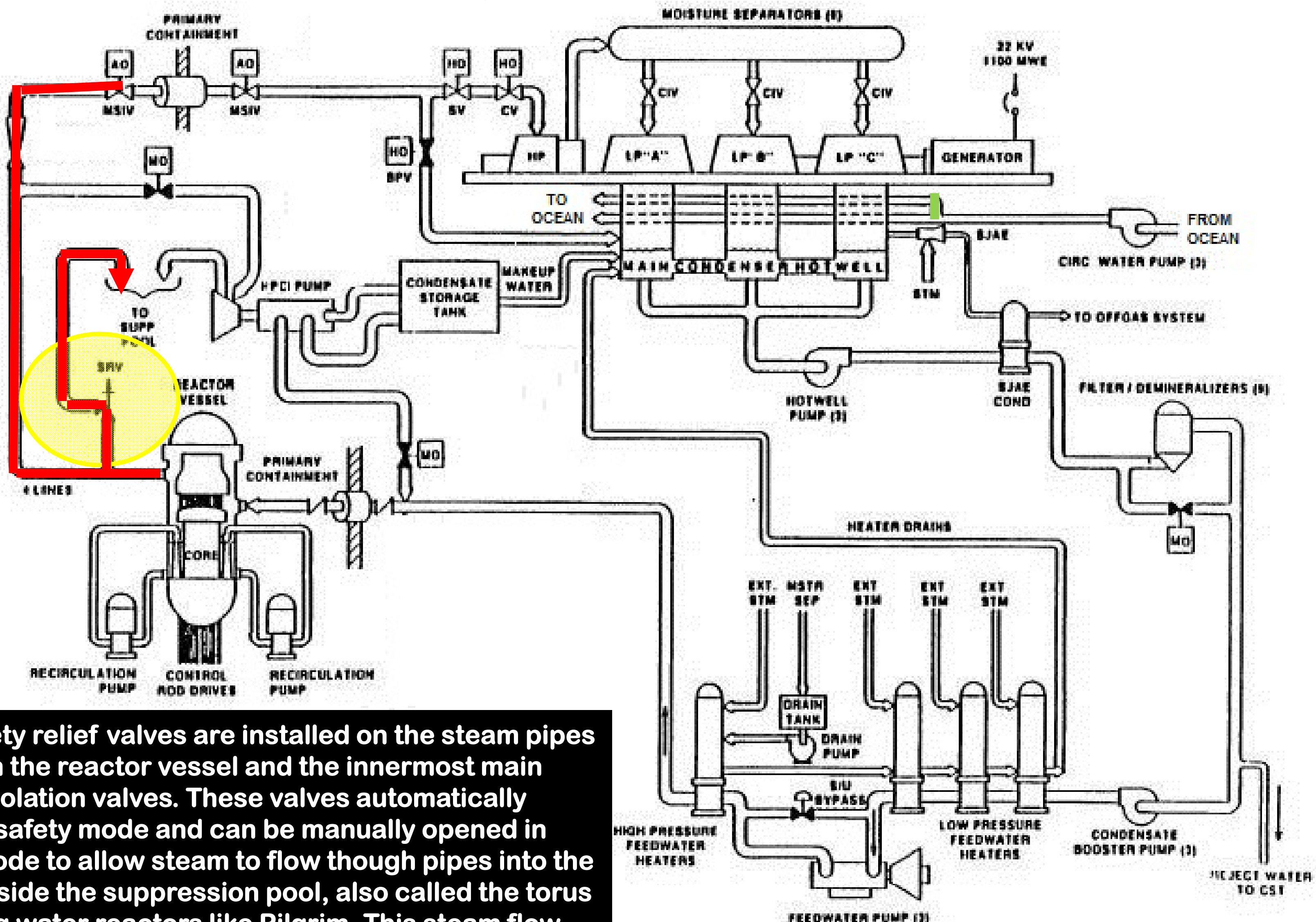
To control pressure inside the reactor, the operators ran the High Pressure Coolant Injection (HPCI) system. It takes steam from the reactor vessel to spin a turbine. The steam exits the HCPI turbines and flows into the torus.

The HPCI pump took water from the Condensate Storage Tank and returned it to the CST.

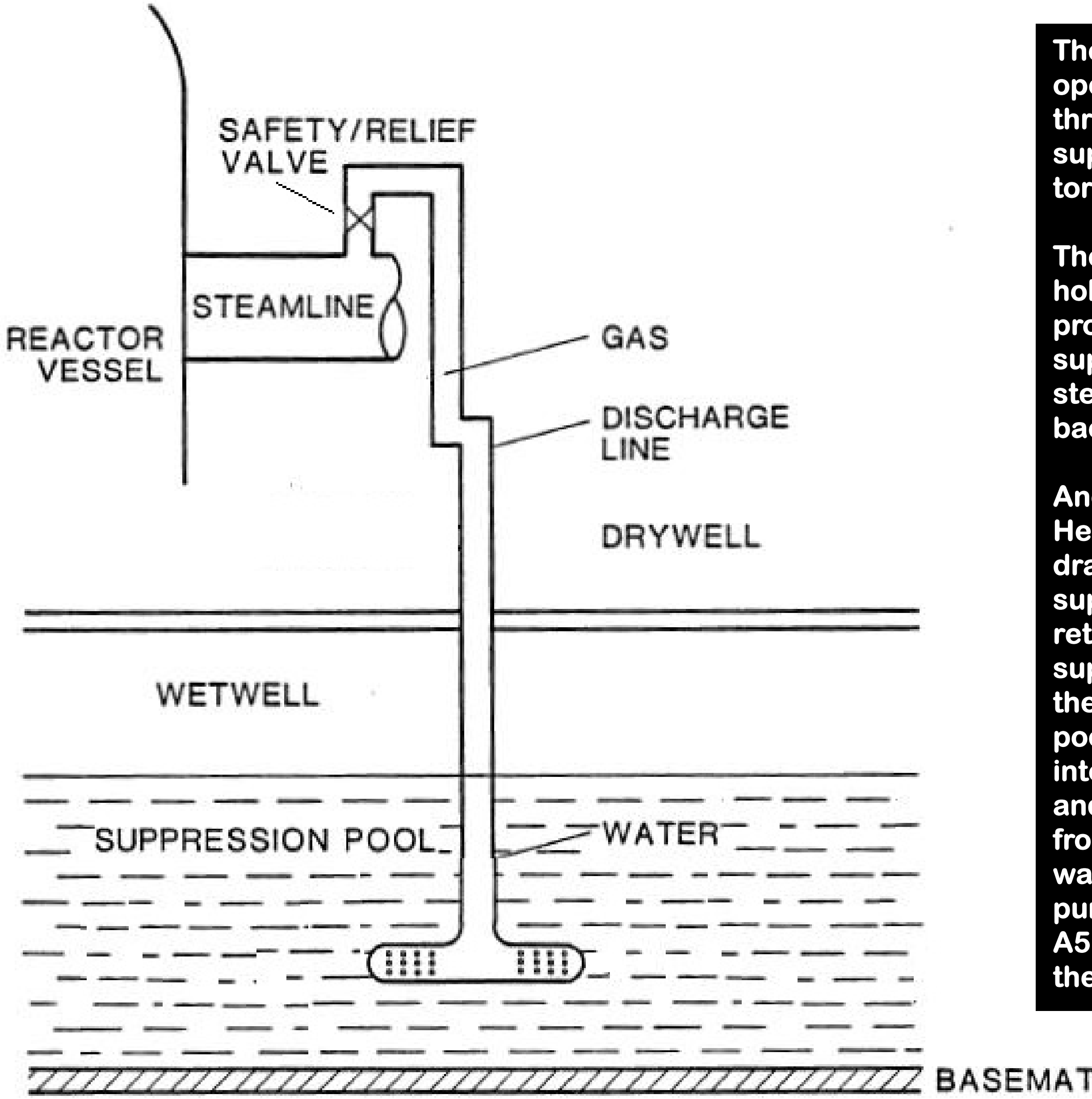
Makeup to the reactor vessel to compensate for the inventory loss (e.g., the fluid leaving as steam to HPCI), was being provided by the Reactor Core Isolation Cooling (RCIC) system. Like HPCI, RCIC uses steam from the reactor vessel to spin a turbine connected to a pump. Thus, it also serves to control pressure. But HPCI is nearly 10 times larger than RCIC and thus does a better job controlling pressure.

Operators had to turn HPCI off, reportedly due to a problem with the gland seal blower.

After HPCI was turned off, operators opened safety/relief valves to discharge steam from the reactor vessel through pipes into the torus.



The safety relief valves are installed on the steam pipes between the reactor vessel and the innermost main steam isolation valves. These valves automatically open in safety mode and can be manually opened in relief mode to allow steam to flow though pipes into the water inside the suppression pool, also called the torus in boiling water reactors like Pilgrim. This steam flow lowers the pressure inside the reactor vessel. The valves close automatically in safety mode when the pressure decreases sufficiently.



The steam flowing through an open safety relief valve travels through a pipe into the suppression pool (also called torus and wetwell).

The steam leaves through small holes drilled in the pipe that promote mixing with the suppression pool's water. The steam is cooled and condensed back into water.

Another system - the Residual Heat Removal or RHR system – draws water from the suppression pool, cools it, and returns the cooled water to the suppression pool. This retains the capacity of the suppression pool to absorb energy released into it via the safety relief valves and from the steam exhausted from the HPCI system while it was running. The RHR system pumps are powered from Buses A5 and A6, which are supplied by the emergency diesel generators.

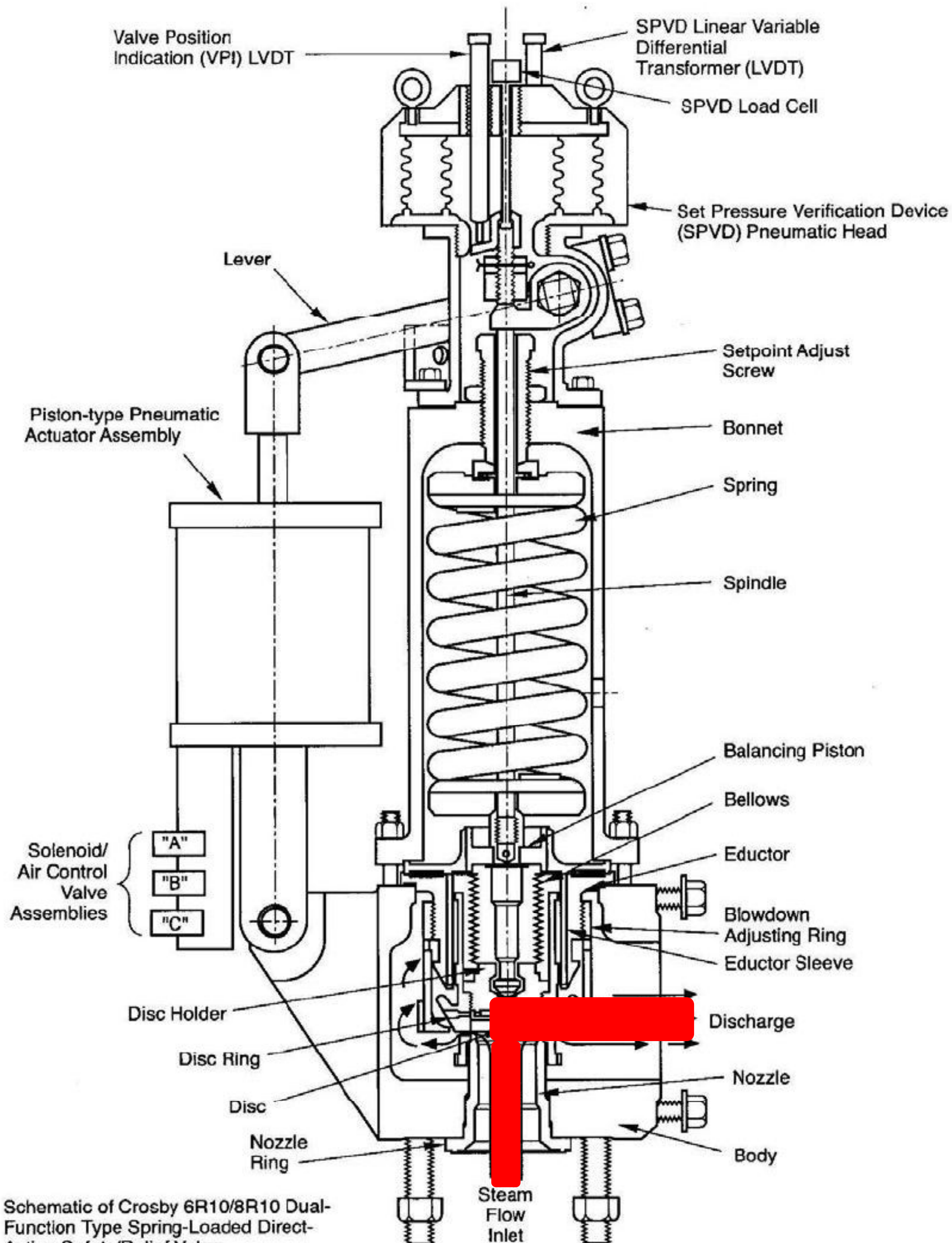
This shows a cutaway side view of a safety relief valve representative of those at Pilgrim.

When opened, steam flows up into the valve and immediately turns right to enter the pipe carrying it to the suppression pool.

The large spring keeps the safety relief valve normally closed.

When the pressure inside the reactor vessel rises above the set pressure, that force pushes against the spring to open the valve. When reactor vessel pressure is sufficiently reduced, the spring overcomes the force to reclose the valve.

The operators can manually open the valve by turning a switch in the control room. This causes a solenoid valve to open that admits compressed air. The compressed air pushes against the spring to open the valve. The valve stays open until the operators turns the switch to close the solenoid valve (or when the compressed air supply is exhausted).



Schematic of Crosby 6R10/8R10 Dual-Function Type Spring-Loaded Direct-Acting Safety/Relief Valve

Ironically, the NRC announced on Groundhog Day that it was dispatching a special inspection team to Pilgrim to investigate the reasons for the initial loss of the offsite power lines and ensuing problems the operators encountered, including the failure of the HPCI system, the inability to open one safety relief valve from the control room, and the failure of the standby diesel powered compressor to start. Like Bill Murray's character in the feature film *Groundhog Day*, Pilgrim seems to be reliving certain things over and over. And over. And over.

Recurring HPCI system problems include:

07/22/2013: Company informed NRC that HPCi failed during a periodic test due to miscalibration of a control circuit.

01/30/2012: Company informed NRC that HPCI failed during a periodic test when a control valve malfunctioned.

Recurring safety relief valve problems include:

01/31/2014: Company informed NRC that Pilgrim was shut down due to a leaking safety releif valve that had to be replaced.

12/21/2012: Company updated NRC about the 12/26/2011, problem of excessive leakage through a safety relief vave.

05/29/2012: Company informed NRC that the automatic opening setpoints for three of four safety relief valves were higher than allowed by the operating license.