CALVERT CLIFFS UNIT 1
CYCLE 4

November 12, 1979

PRELIMINARY REPORT OF POWER DISTRIBUTION EPISODE

7 '6 285

CURRENT PLANT STATUS

As of 0000, November 9, 1979, Unit 1 is operating in its fourth cycle at a 50% power level with critical core parameters of the following magnitude:

F_z = 1.19 at 3 feet from bottom of core
F_r = 1.42
F_{xy} = 1.48 at 3.4 feet from bottom of core
T_q = .009
Core Average Burnup = 3,279 MWD/t
Internal Axial Shape Index = +.075

Reactor power had been reduced from 80% to 50% during the period 1700, November 7, to 0300, November 8, and an axial Xenon oscillation is still in progress.

NARRATIVE RELATIVE TO EXPERIENCE THROUGH NOVEMBER 8, 1979

At approximately 0800, October 22, 1979, the Plant Nuclear Engineer observed that the Axial Shape Index (ASI), Planar Radial Peaking Factor (F_{xy}), and Integrated Radial Peak (F_r) had been steadily increasing since the previous week. Azimuthal tilt (T_q) had been holding steady at about .006. Predictions indicated that F_r and F_{xy} should experience a very slow decrease in magnitude with core burnup.

During the next three days, the Plant Staff increased surveillance on the critical core parameters from once every eight hours to once every hour and prepared local power distribution maps in order to assess the degree of local change in power distribution since October 13. In addition, a systematic review of other plant information was begun. Specifically, beginning with Cycle 4 Startup, trends of the following parameters were evaluated:

- Hydrogen Overpressure in the Volume Control Tank
- Differential pressure across Reactor Core and Reactor Coolant Pumps
- Hydrogen concentration in the Reactor Coolant System.

NARRATIVE (cont'd)

On October 25 a package of raw core power distribution data was forwarded to Combustion Engineering for analysis in accordance with a standard core verification program performed for Calvert Cliffs by Combustion Engineering. At about 0800 on October 25, the measured peak linear heat rate was 10.7 Kw/ft, F_r was 1.45, F_{xy} was 1.56, T_q was about .007, and Internal Axial Shape Index was +7.6%. Out of a precautionary concern for fuel integrity, the Plant Nuclear Engineer limited reactor power such that a summation of measured power level plus the Axial Shape Index would not exceed 108%.

On October 26, the Plant Nuclear Engineer began a periodic transmittal of core parameter trend data to CE. See Figures 1 and 2.

On October 26, the Plant Staff suspected the cause of the increasing pressure drop across the reactor core was due to an increasing crud deposition on fuel surfaces and began a search for sources of Oxygen to the Reactor Coolant System. During this time it was also observed that trend data indicated a lower than normal Hydrogen concentration in the Volume Control Tank. By October 29, the source of Oxygen had been identified and isolated. While Number 11 Deborating Ion Exchanger was in service (See Figure 3), it appears that air was introduced into the purification system via the Instrument Air header which is normally used to assist in spent resin transfer. Apparently, two (2) valves (1-IA-234 and 1-CVC-151) leaked by their seats allowing air to be introduced into the outlet of the ion exchanger. When sampled, the ion exchanger outlet had an Oxygen concentration of 300 ppb. The ion exchangers were bypassed and the Instrument Air header drain valve (1-CVC-154) was opened and left open to ensure that the header remained depressurized thereby precluding introduction of Oxygen into the Reactor Coolant System.

On October 27, CE verified the power redistribution observed by the Plant Nuclear Engineer. The core was experiencing a slowly increasing roll

NARRATIVE (cont'd)

of power toward the core center and toward the core bottom. Whereas predictions did indicate a slow roll in power to the core center, the measured roll was greater than the prediction. The prediction did not indicate a roll in power toward the core bottom.

Early the week of October 29, the Plant Staff and CE concluded that the cause of the power redistribution was a crud buildup on the fuel rod surfaces, preferentially to the top of the core. The crud would contain iron and other oxidized constituents of stainless steel which would act as a mild poison to the fission reaction; and in addition, the crud may change the heat transfer characteristics across the fuel rod resulting in an increasing Doppler feedback effect. This conclusion was also consistent with a small reactivity anomaly evident in a trend of measured versus predicted boron concentration in the Reactor Coolant System. See Figure 4.

On November 1, the Plant Staff and CE began a discussion of strategies for removing crud from the fuel rods. In addition, the Plant Staff began analyzing for Hydrogen at a Reactor Coolant System hotleg sample point. At no time prior to and during the observation of the core power redistribution was Oxygen observed in the Reactor Coolant System. However, as a precaution, the Hydrogen concentration in the Volume Control Tank was increased resulting in a corresponding increase in Hydrogen concentration in the Reactor Coolant System.

On November 2, the Plant Nuclear Engineer directed CE to begin a correlation of crud thickness and other characteristics with reactor power redistribution and in addition, a quantitative evaluation of its effect on the safety analysis.

On November 3, the Plant Chief Engineer organized a Power Distribution Task Force chaired by the Plant Nuclear Engineer and consisting of the Plant Radiation-Chemistry Engineer and the Plant Operations Engineer.

NARRATIVE (cont'd)

On November 5, the I&E Regional Office was informed of the Power Distribution Episode by the Shift Supervisor and also by the Plant Chief Engineer. In addition, the Plant Nuclear Engineer responded to a query from the NRC Project Manager for Calvert Cliffs. At this time no plant technical specifications had been exceeded. The parameter closest to the limit was F_{xy}^{T} which was measured at 1.64. Limit is 1.66.

On November 6, CE informed the Task Force that CE's preliminary evaluation revealed the possibility of lithium concentration in the presence of local boiling in the porosities of the crud layer. Therefore, CE recommended a decrease to 80% power in order to alleviate that concern and to gain more margin. The Task Force concurred and reactor power was decreased to 80%.

By November 7, the strategy for removing crud had been developed. Lithium concentration would be increased slightly from less than 1 ppm to about 2 ppm in the Reactor Coolant System, thereby raising pH and creating an environment for slow dissolution of the crud layer. At this time CE had completed their evaluation and determined that the appropriate power level for precluding local boiling in crud porosities at the hottest point in the core was 50%. CE recommended that the increase in lithium concentration in RCS take place at that power level. The Task Force concurred.

In addition to determining the cause of and resolving the power maldistribution, a charge to the Task Force is to keep the Plant and Offsite Safety Committees informed. The Plant Safety Committee has been briefed periodically since November 5 and on November 8 the Task Force made a written report to the Offsite Safety Committee.

By November 8, the reactor had been stabilized at 50% power and lithium additions to the Reactor Coolant System begun in order to gain and maintain the concentration in the RCS at about 2 ppm. The purification ion exchanger was put back in service.

NARRATIVE (cont'd)

The most limiting core parameters observed to date have been F_{xy}^T equal to about 1.655 and F_z equal to 1.24 at 1410, November 6, 1979. The peak increase in the differential pressure across the core occurred on October 25 and was about 1.7 psi above a nominal value of about 13.8. See Figures 1 and 2. Note that the differential pressure across the core has slowly decreased since then. Since the source of Oxygen has been isolated from the Reactor Coolant System and the Hydrogen concentration in the Reactor Coolant System has been increased, this decrease in core DP is postulated to be caused by a reduction in the oxidization state of the crud layer which has smoothed the crud surface thereby reducing resistance to water flow.

During the initial startup test program on Unit 1 in late-1974, the differential pressure across the core increased by about 3 psi. The Unit 1 Startup Test Report dated August 29, 1975, provides more detail. The reactor was ultimately shutdown, the reactor vessel disassembled, and an inspection made for mechanical flow blockage as well as crud deposition on the fuel rods. Mechanical scraping of selected fuel assemblies revealed no apparent crud layer. No mechanical flow blockage was evident. The reactor vessel was re-assembled and the startup test program re-initiated. Differential pressure across the core slowly decreased over a period of several months to a normal value. No unexpected power distributions were observed coincident with the increase in differential pressure across the core above its normal value.

FUTURE PLANS

Present intentions are to maintain lithium concentration at about 2 ppm while observing Reactor Coolant System samples for crud releases and the core parameters for a beneficial change. In addition, CE is determining a combination of higher reactor power level and lower RCS temperature which is consistent with precluding local boiling in crud porosities at

FUTURE PLANS (cont'd)

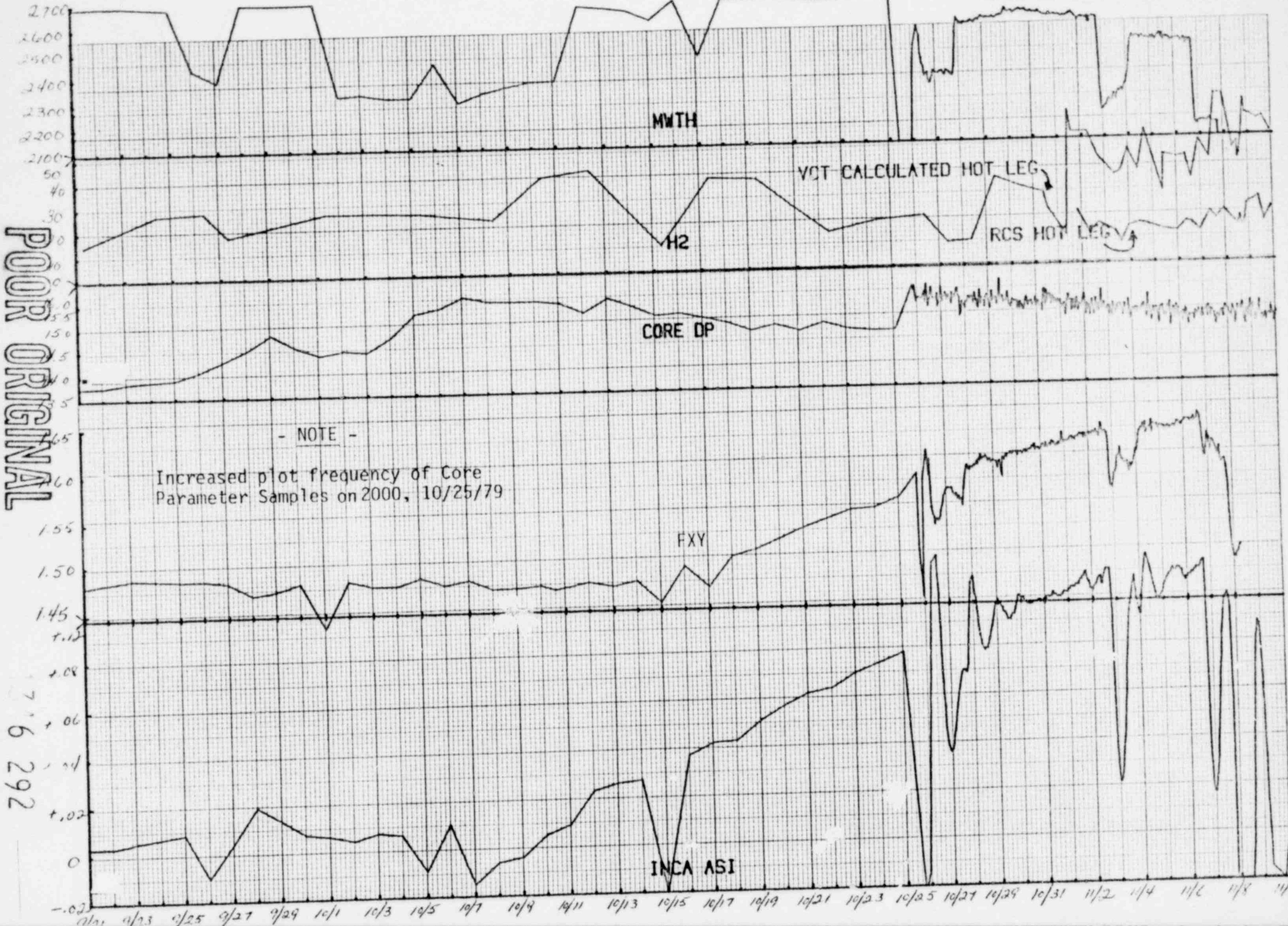
the hottest point in the core. A preliminary evaluation is that the appropriate combination of reactor power level and RCS temperature is 60 - 65% and T_c equal to 515 - 520°F. When that evaluation is finalized reactor power will be raised to the appropriate value.

Correlation of crud characteristics (thickness, nuclear cross section, thermal conductivity) with the as-experienced power redistribution is still being evaluated. Reactor power will be increased to a level consistent with the effect of that evaluation on the Safety Analysis and fuel integrity. In addition, reactor power will be increased consistent with improvement in the measured value of core parameters.

Alternative methods for removing or decreasing the crud buildup on fuel rod surfaces are being considered. As yet no decision has been made to implement them.

FIGURE 1

CORE PARAMETERS
UNIT-1, CYCLE 4



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CORE PARAMETERS UNIT-1, CYCLE 4

FIGURE 2

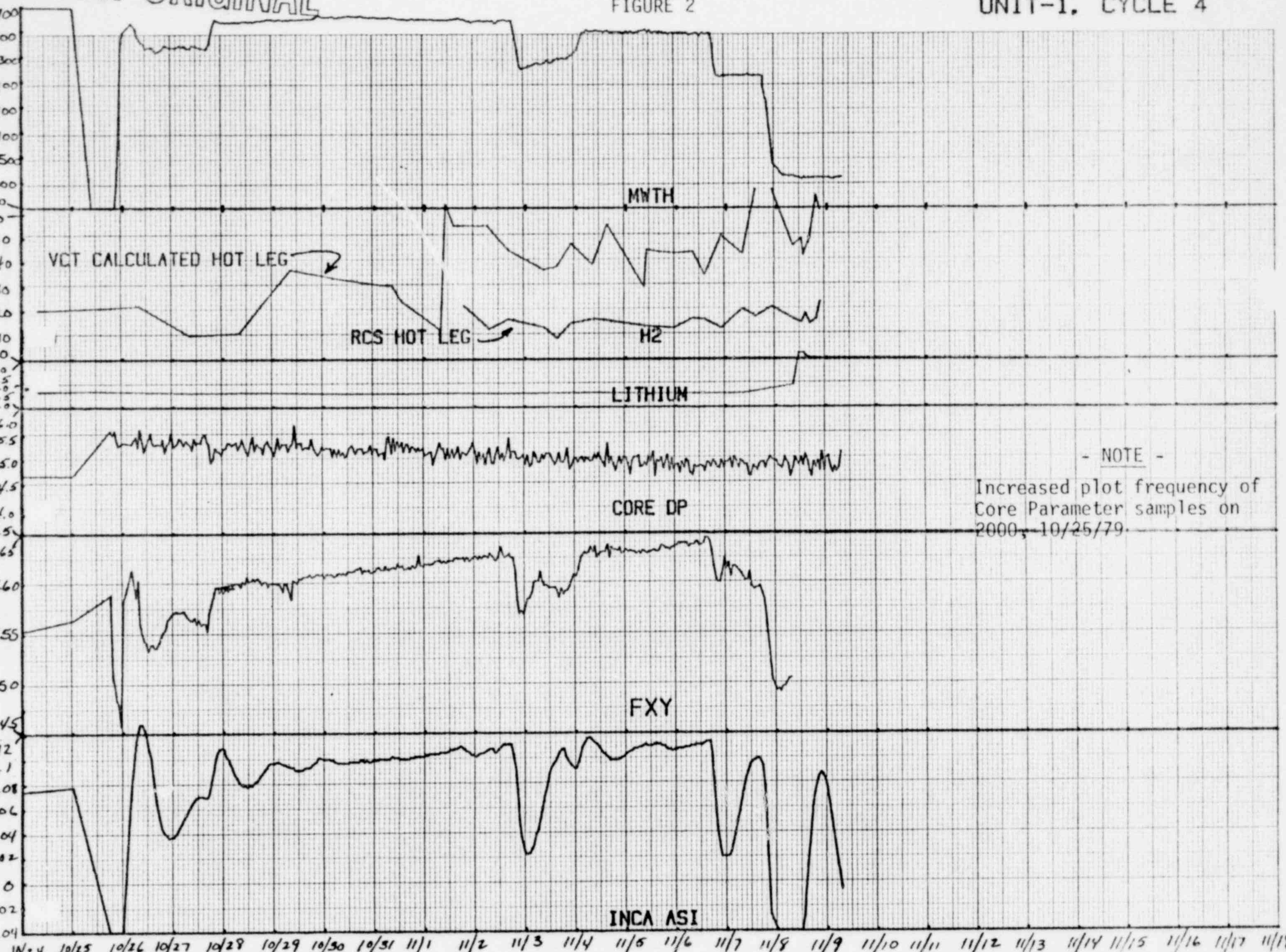

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FIGURE 3

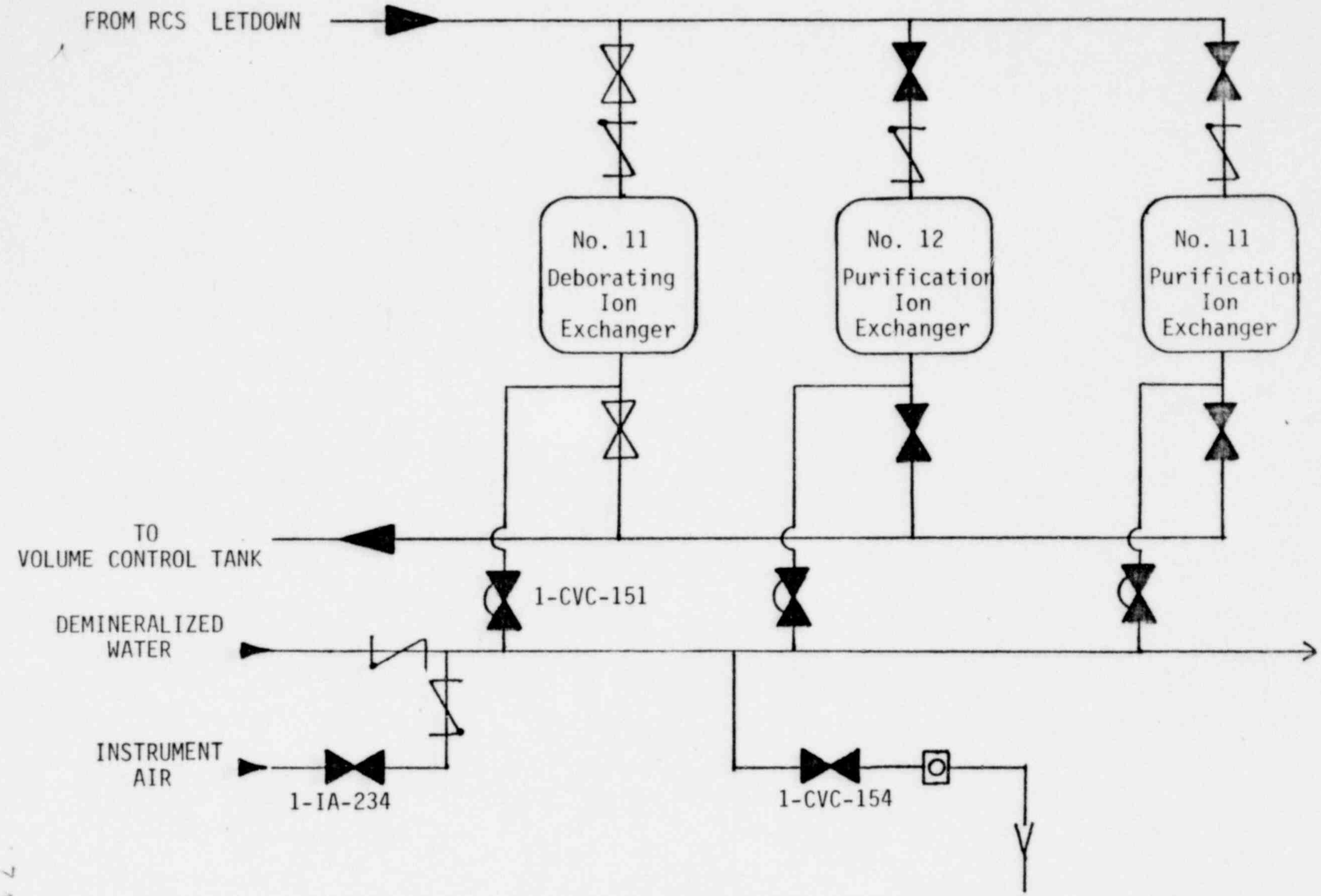

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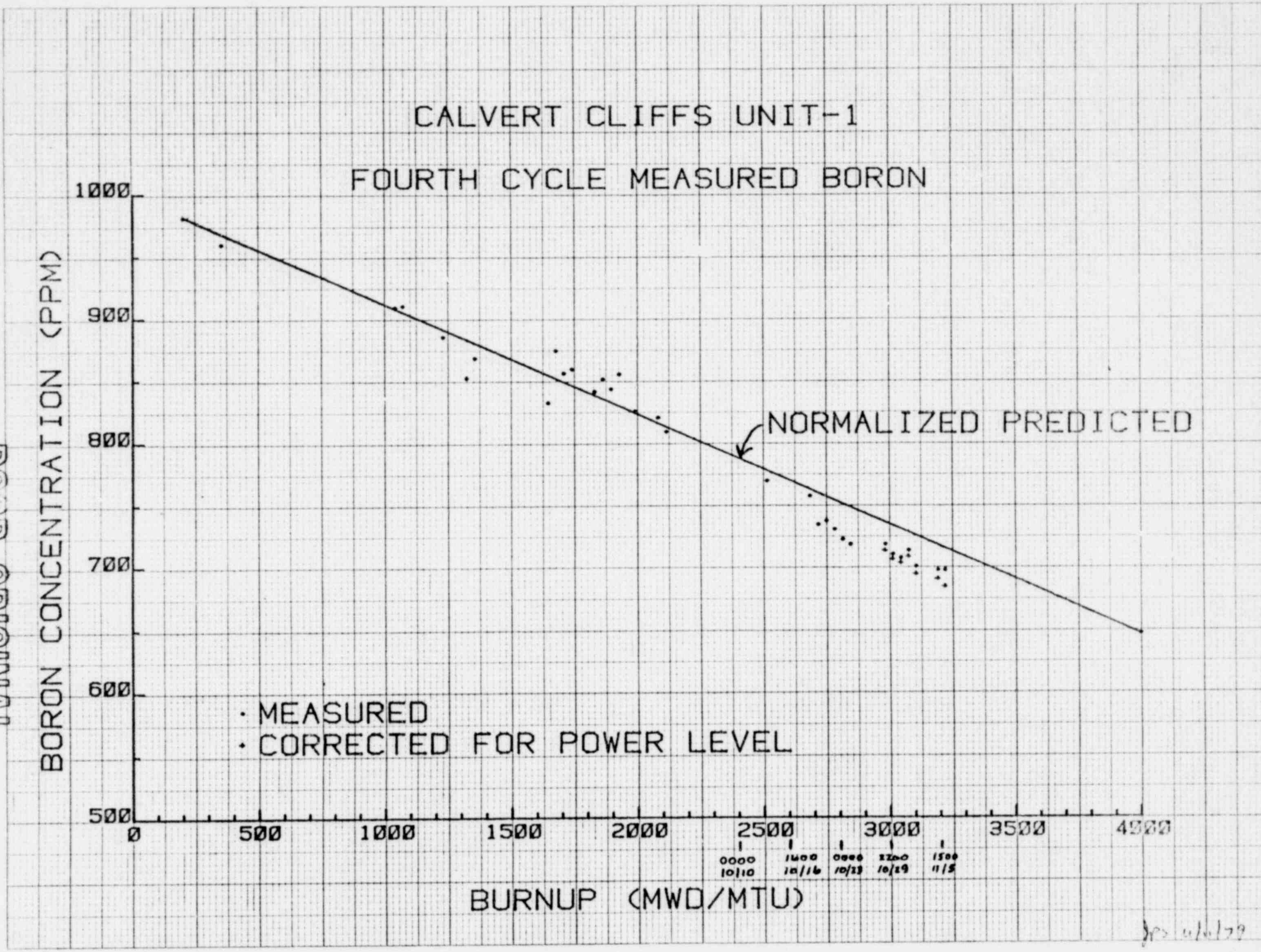
FIGURE 4



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