AMAG Feedwater Measurement Primer

B-8

Developed by

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and

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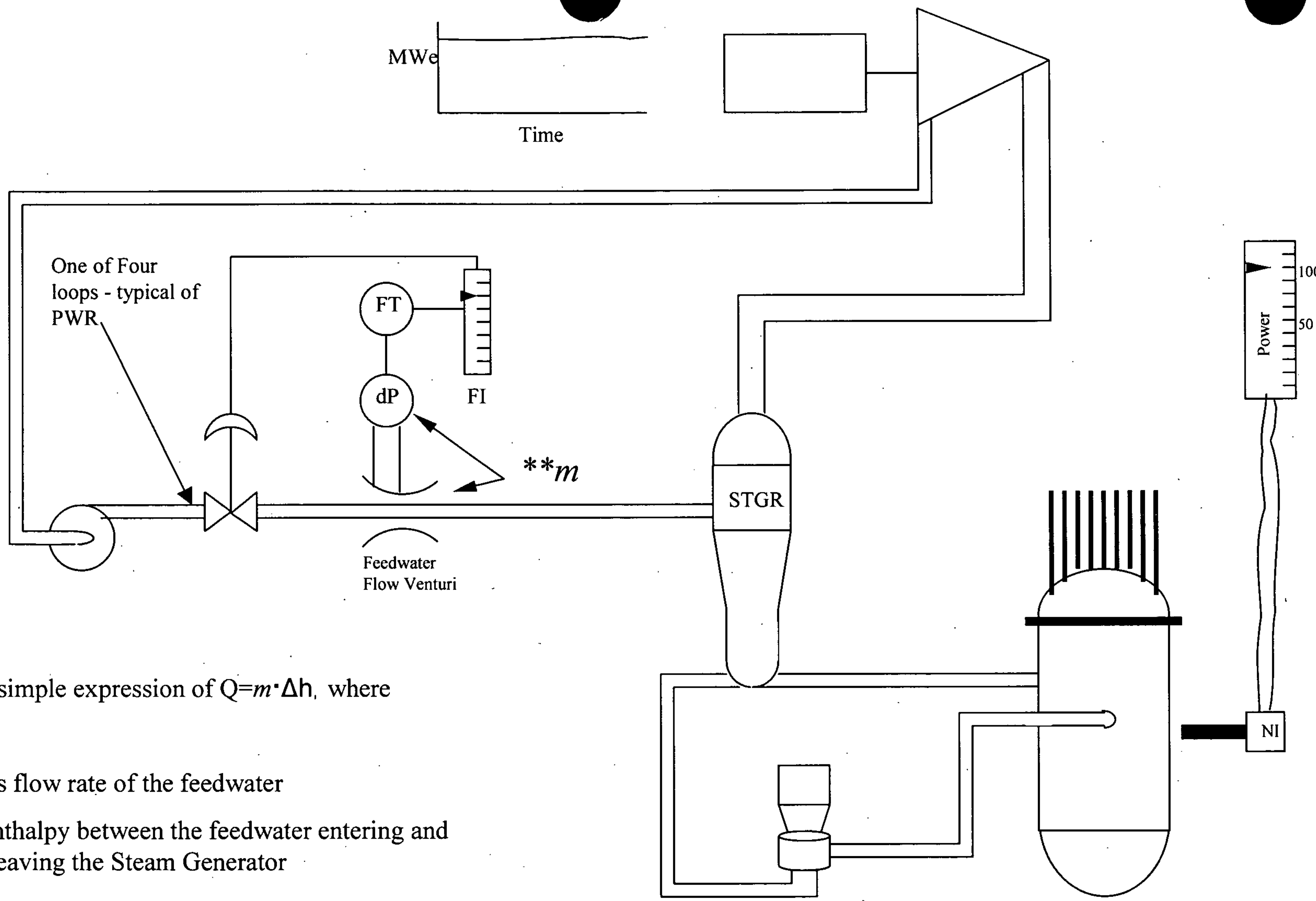


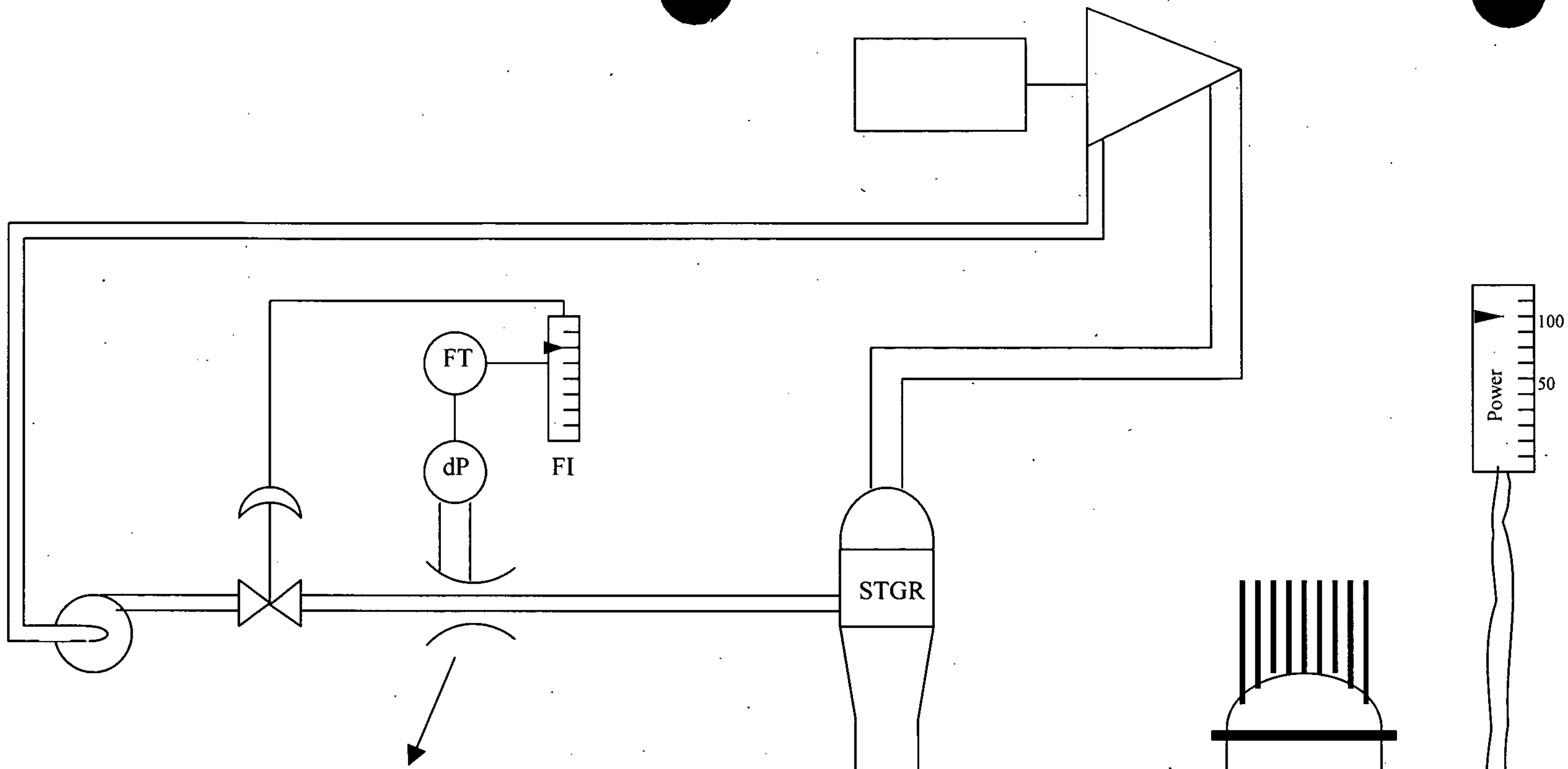
Power is a simple expression of $Q=m \cdot \Delta h$, where

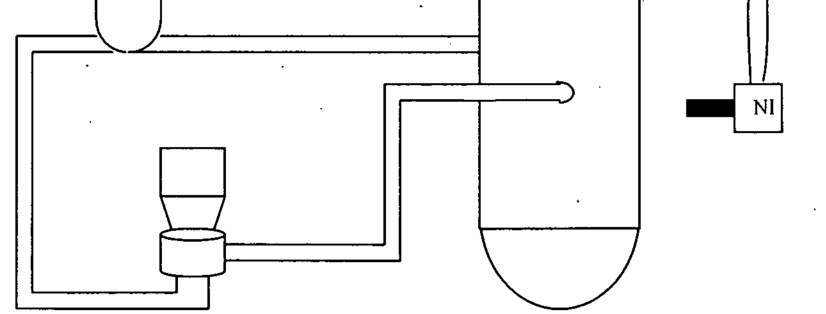
Q = power

**m = mass flow rate of the feedwater

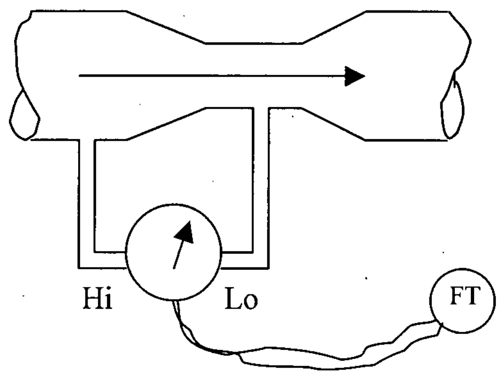
Δh = the enthalpy between the feedwater entering and the steam leaving the Steam Generator

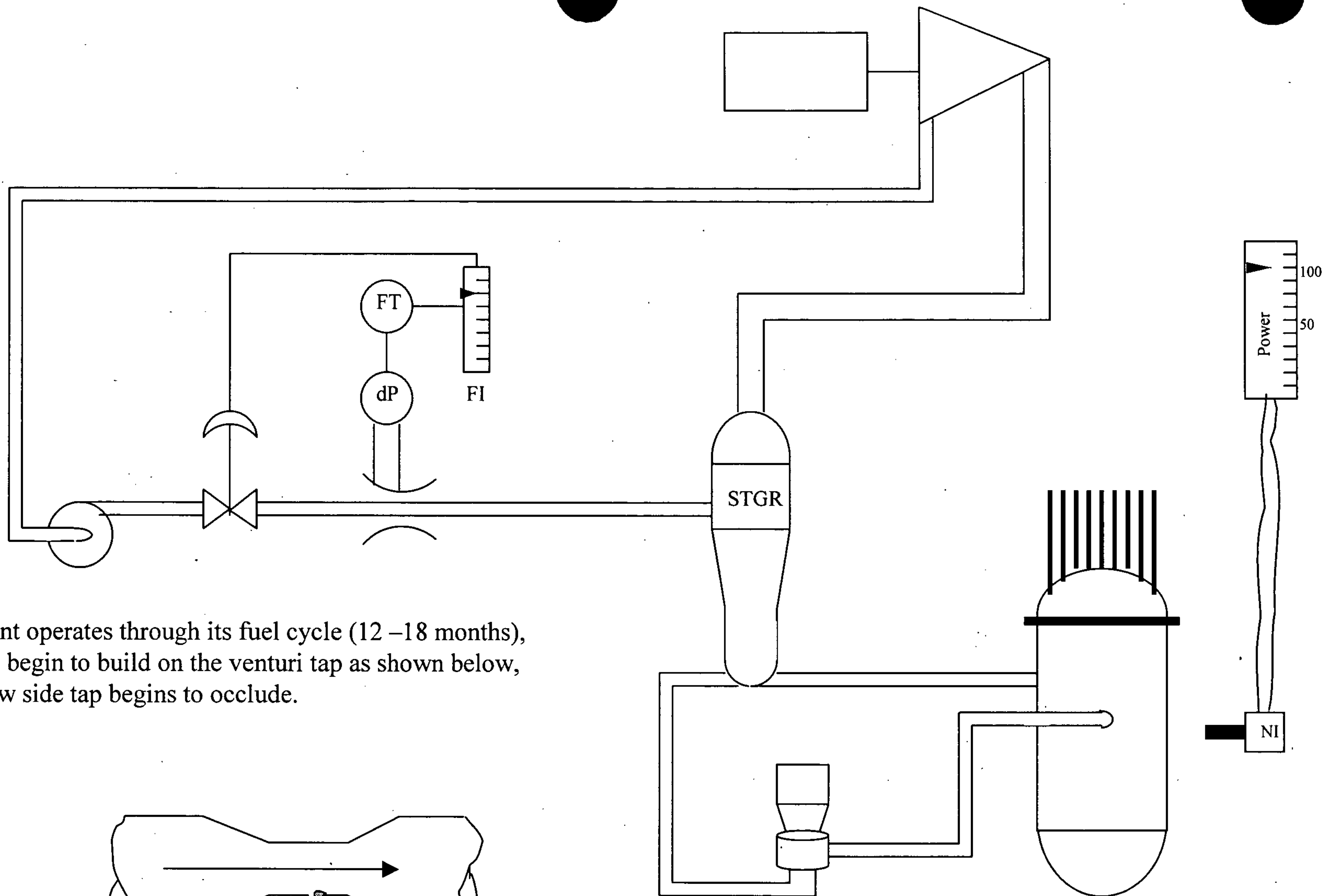
**The mass flow rate (m) is of particular interest as it is a function of indicated venturi flow



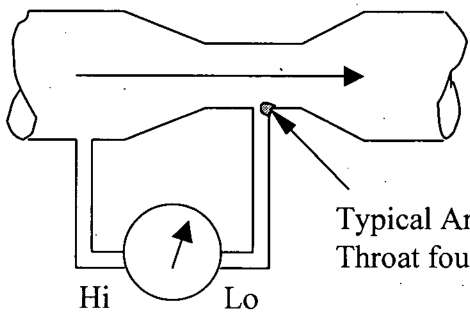


A cross section of a typical Feedwater Venturi as installed in the Feedwater piping is shown below:

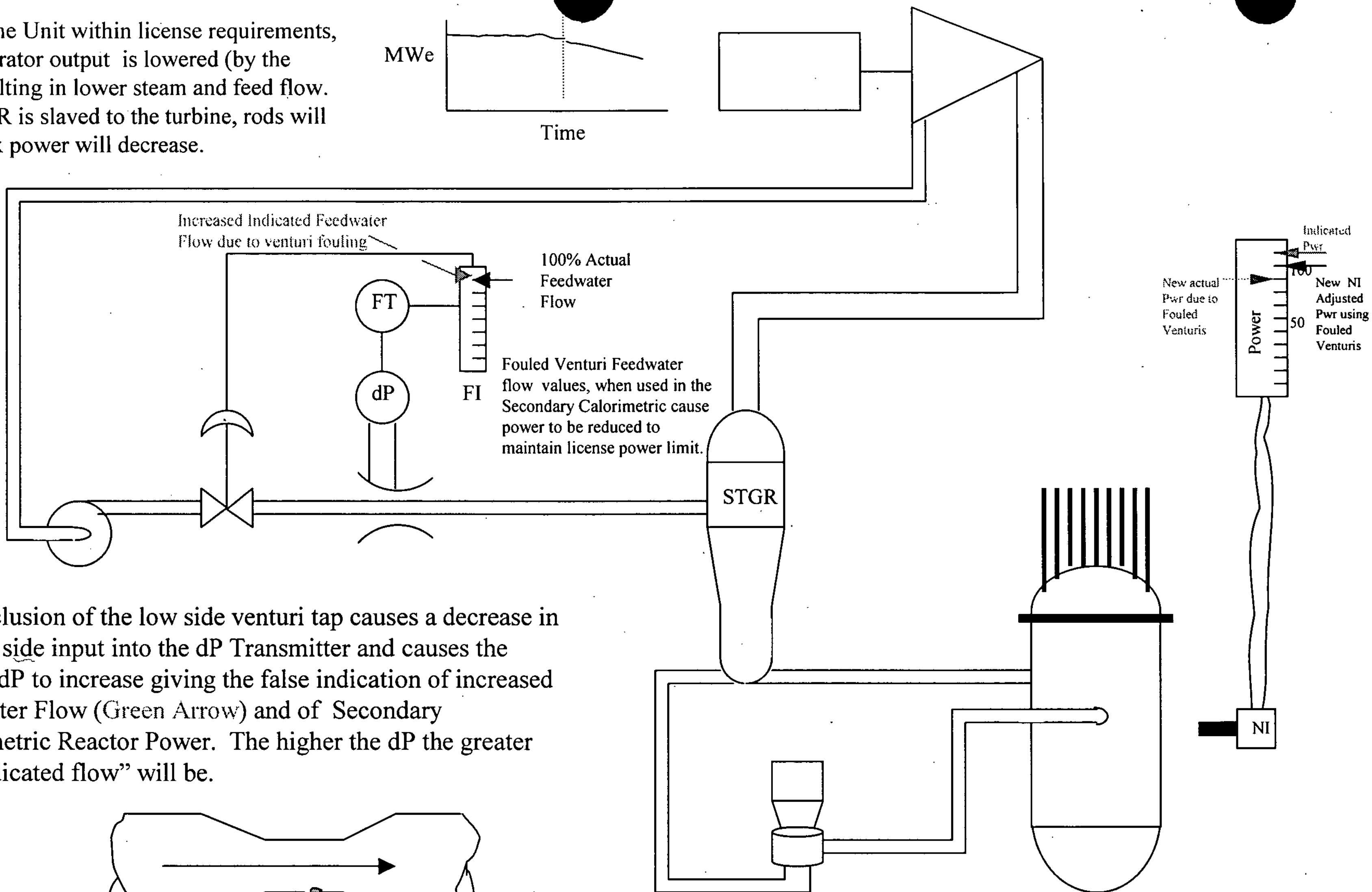




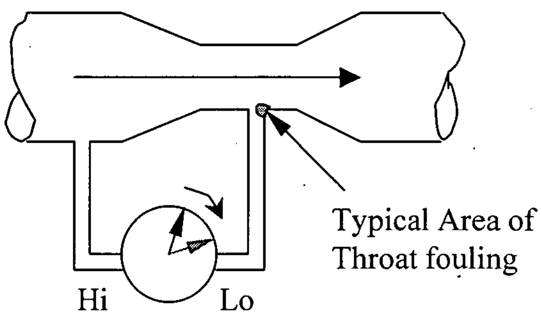
As the plant operates through its fuel cycle (12 –18 months), impurities begin to build on the venturi tap as shown below, and the low side tap begins to occlude.

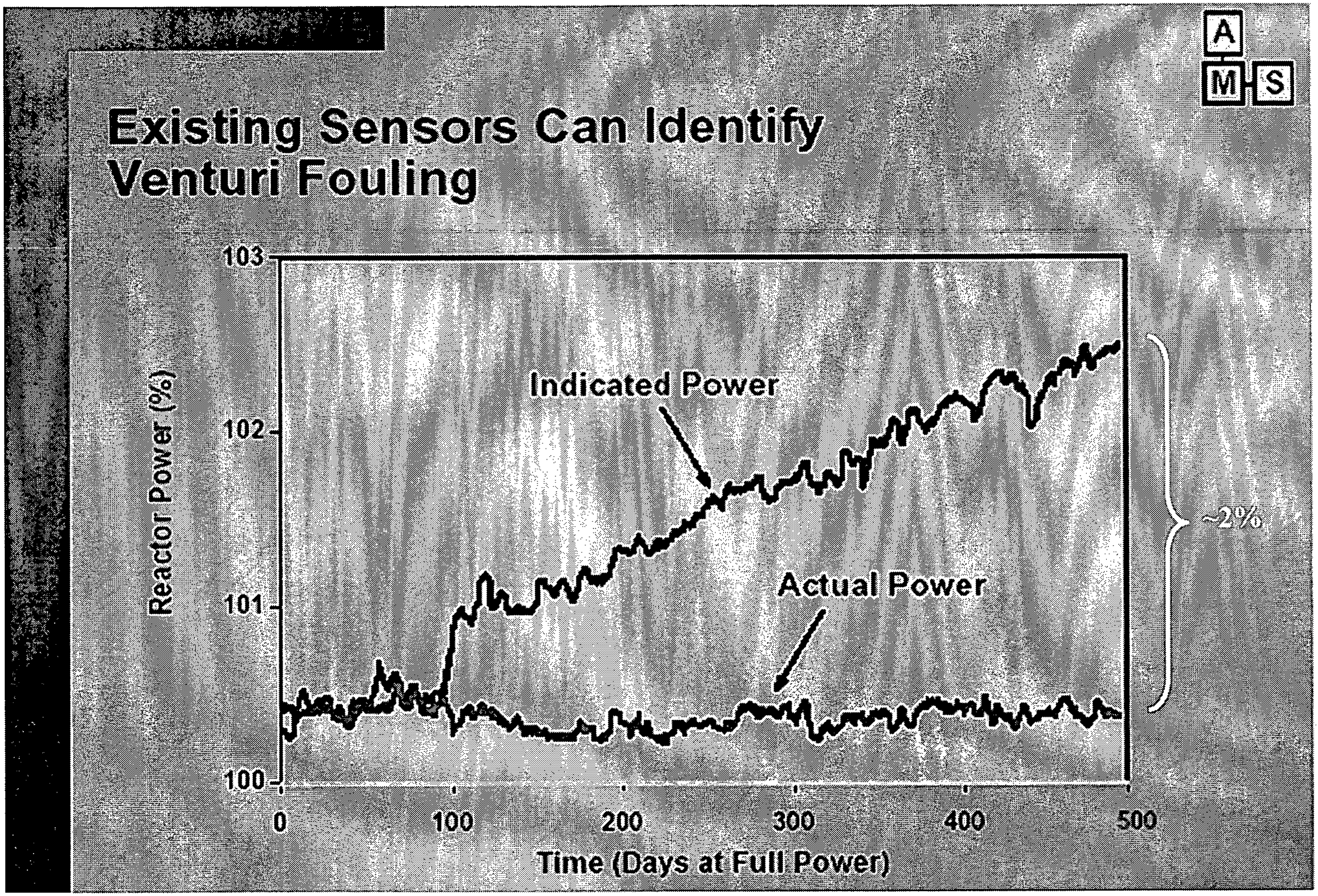


To maintain the Unit within license requirements, Turbine/Generator output is lowered (by the operator) resulting in lower steam and feed flow. Since the PWR is slaved to the turbine, rods will step in and Rx power will decrease.

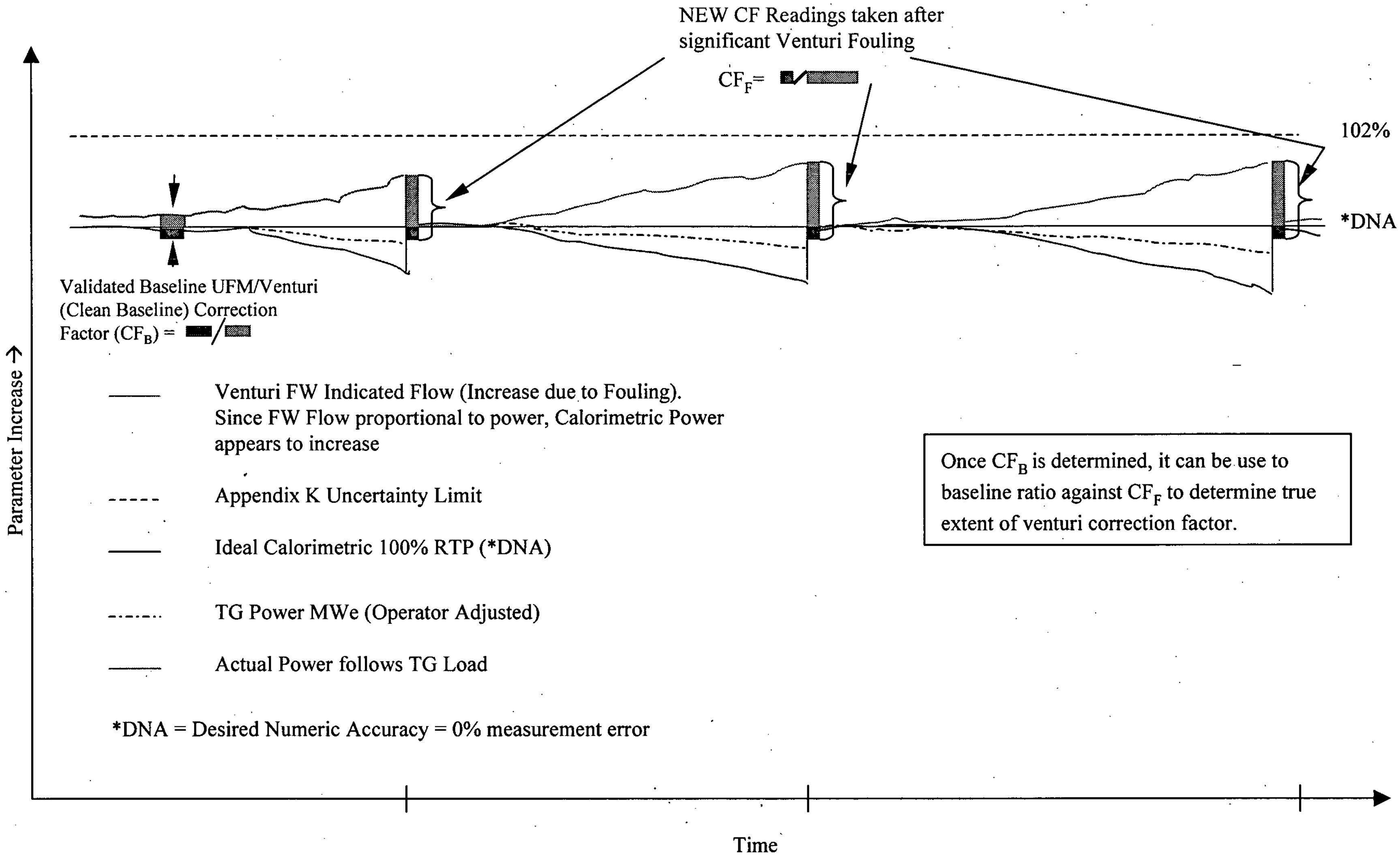


The occlusion of the low side venturi tap causes a decrease in the low side input into the dP Transmitter and causes the overall dP to increase giving the false indication of increased Feedwater Flow (Green Arrow) and of Secondary Calorimetric Reactor Power. The higher the dP the greater the "indicated flow" will be.





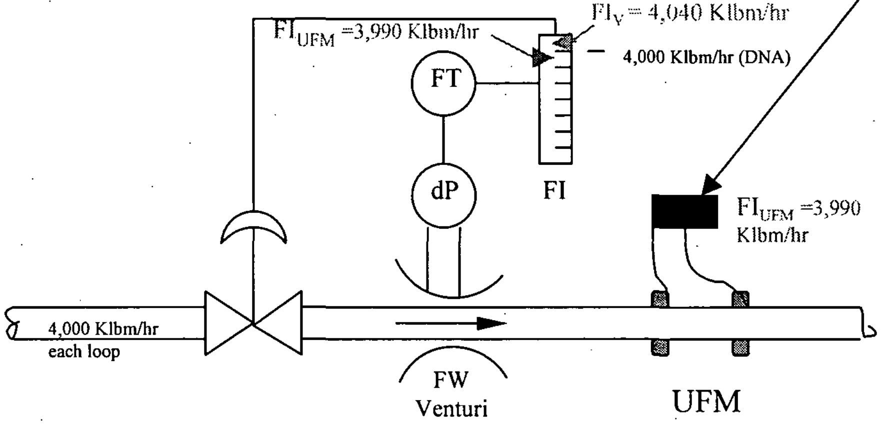
Existing Sensors Can Identify Venturi Fouling
AMS
Indicated Power
Actual Power
~2%
Reactor Power (%)
103
102
101
100
0
100
200
300
400
500
Time (Days at Full Power)

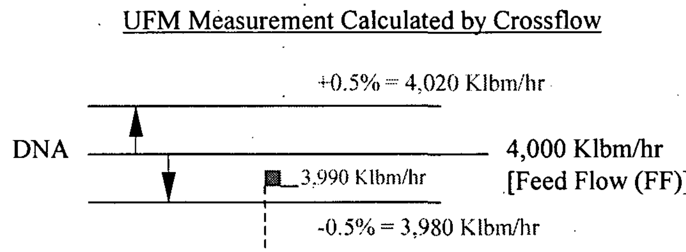


Typical Time vs. Process Parameter regarding Venturi fouling at a 4-loop PWR

Venturi Fouling over time and severe enough will cause higher "indicated" flow, and when this value is placed into the Secondary Calorimetric it will result in actual flow being reduced to maintain a 100% calculated power value based on the Venturis. So for example, with a venturi fouling of 1.0%, the logic would follow as described below.

The newer state-of-the-art Ultrasonic Flow Measuring (UFM) devices measure accurate flow with a 95% confidence interval that the measured value obtained would be ≤ .5% in accuracy uncertainty. So for example, if an AMAG reading were taken an found to be 3,990 Klbm/hr, the correction factor could be developed as described bellow.



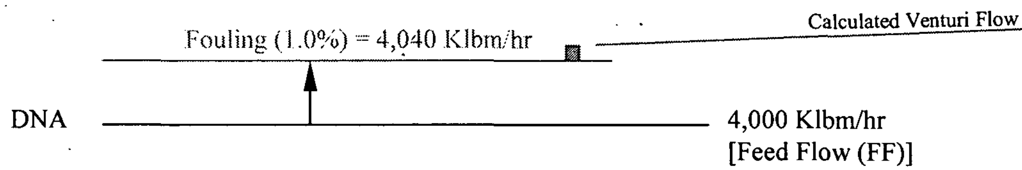


Therefore, if the Correction Factor *CF = UFM (FF)/Venturi (FF) were the worse case...

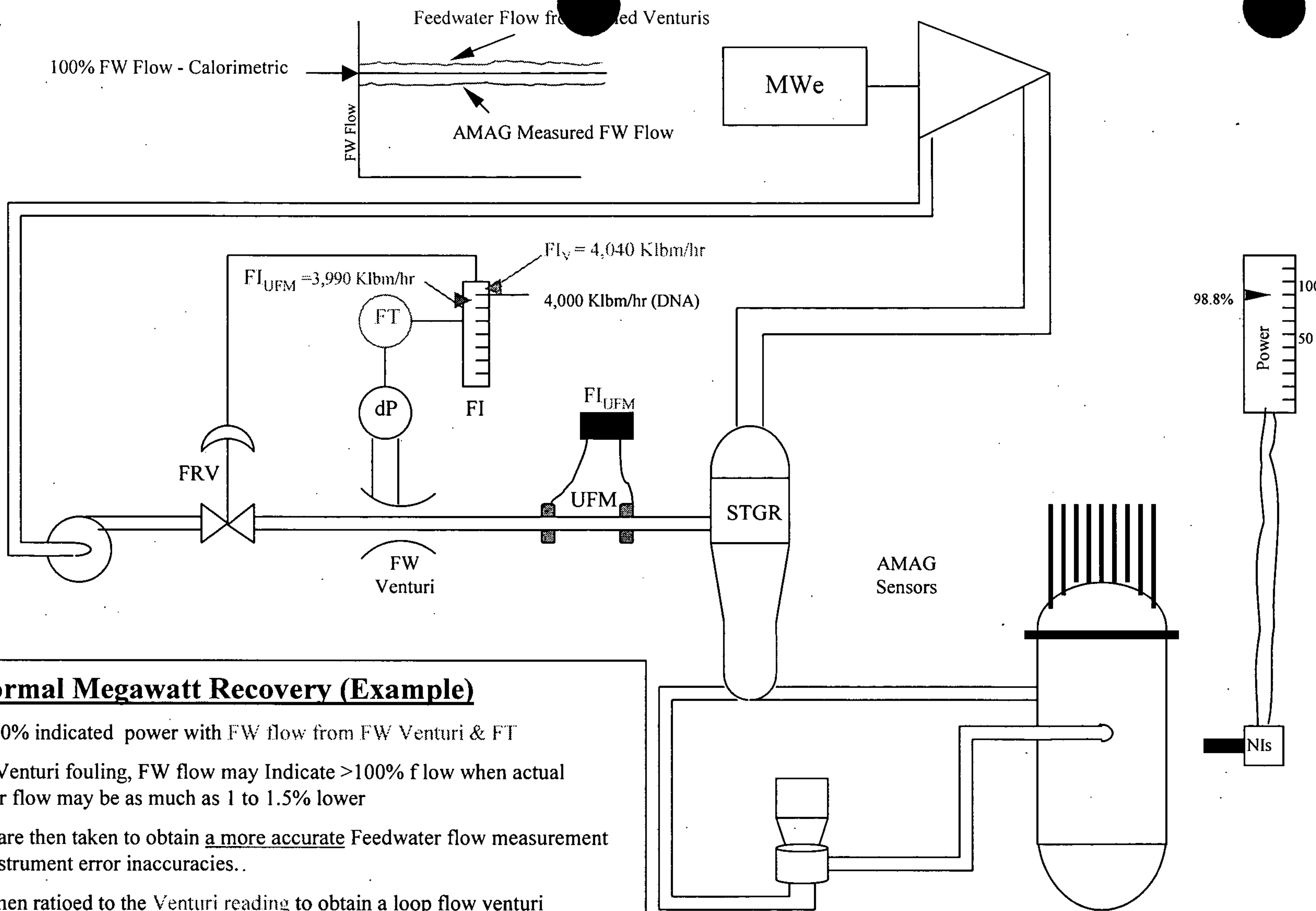
then *CF= 3,990/4,040 = 0.988

Venturi fouling of 1% above DNA Venturi Flow

DNA means desired numeric accuracy = Ideal Accuracy ="0" deviation



*Must be normalized for baseline and uncertainties



Steps for Normal Megawatt Recovery (Example)

1) Rx Power at 100% indicated power with FW flow from FW Venturi & FT

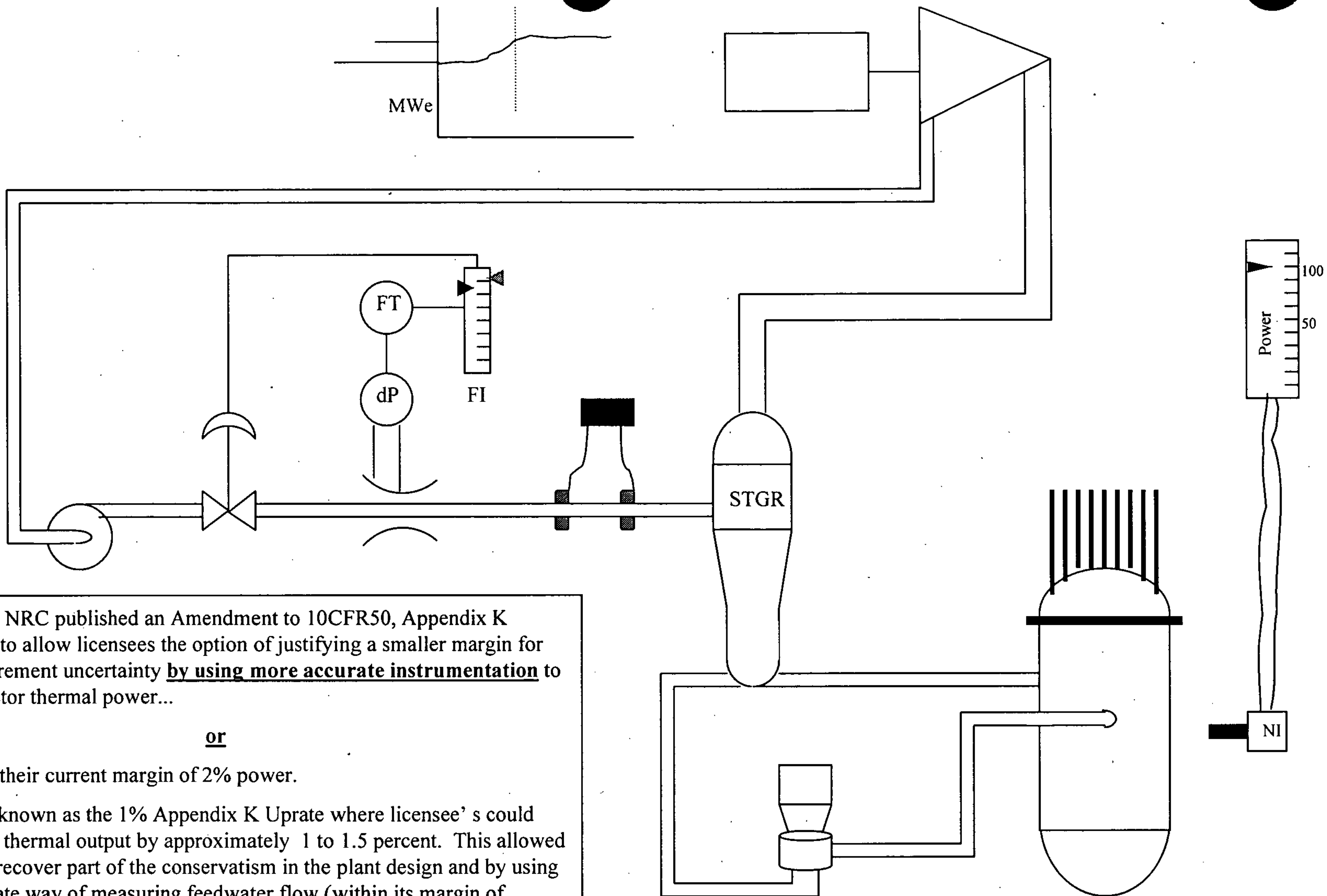
2) Depending on Venturi fouling, FW flow may Indicate >100% f low when actual feedwater flow may be as much as 1 to 1.5% lower

3) UFM readings are then taken to obtain <u>a more accurate</u> Feedwater flow measurement within instrument error inaccuracies..

4) UFM value is then ratioed to the Venturi reading to obtain a loop flow venturi correction factor. In the case of the values above, CF = FI_{UFM} / FI_V = 3990 Klbm/hr / 4040 Klbm/hr = 0.988. Since the CF represents the ratio of what UFM reads in relation to venturi, the correction factor can be applied to the calorimetric and NIs adjusted by operations to that level.

5) The NIs are then adjusted down from their 100% indicated power output to read 98.8%

6) Power is then raised through BOP Turbine-Generator until calorimetric power is back near 100% rated thermal power value.

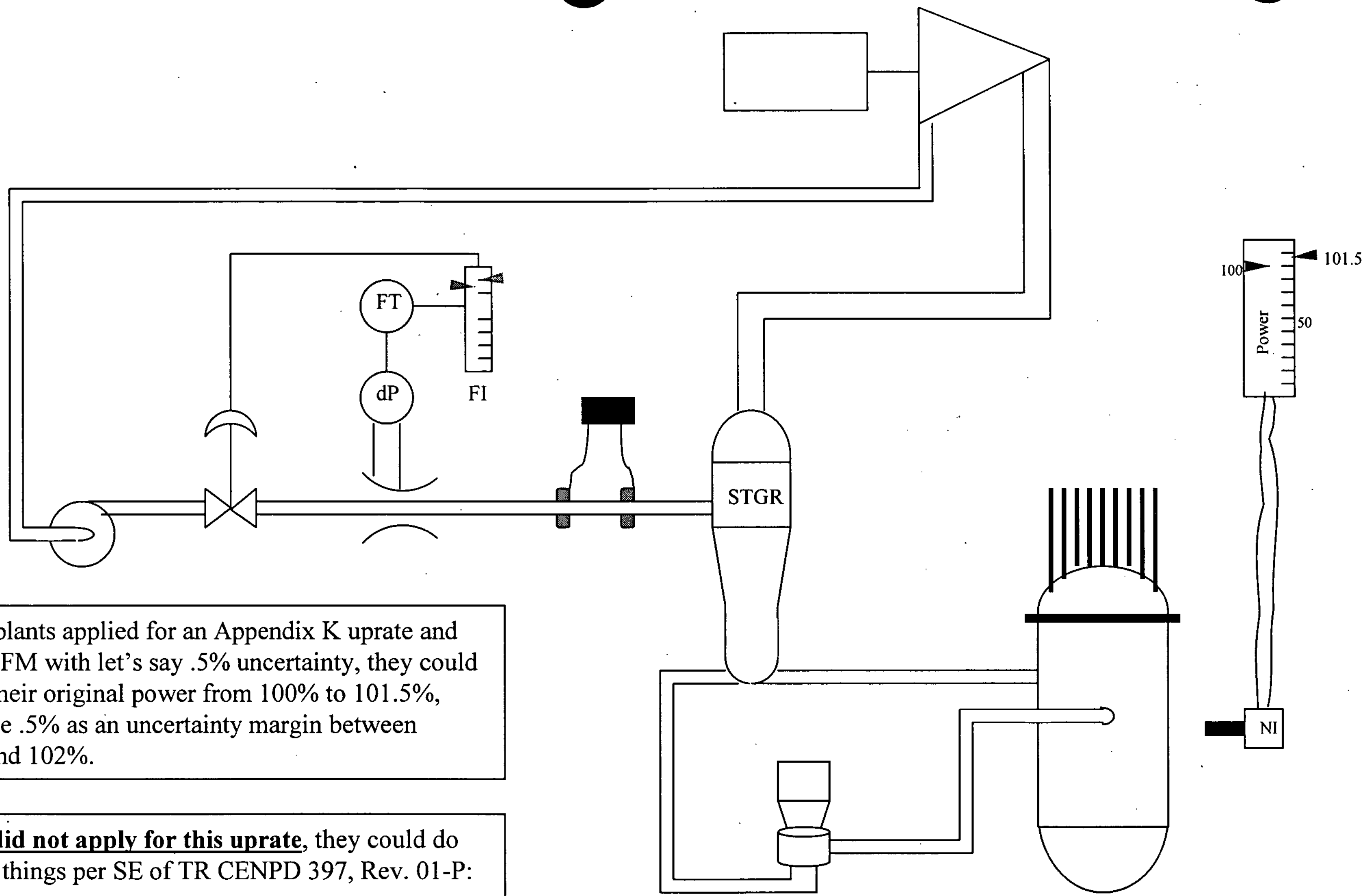


In June 2000, NRC published an Amendment to 10CFR50, Appendix K requirements to allow licensees the option of justifying a smaller margin for power measurement uncertainty **by using more accurate instrumentation** to calculate reactor thermal power...

or

just maintain their current margin of 2% power.

This became known as the 1% Appendix K Uprate where licensee' s could increase their thermal output by approximately 1 to 1.5 percent. This allowed licensee's to recover part of the conservatism in the plant design and by using a more accurate way of measuring feedwater flow (within its margin of accuracy) would allow a unit to remove some of the instrument uncertainty and run closer to 102% of the original licensee power.



So when plants applied for an Appendix K uprate and utilized UFM with let's say .5% uncertainty, they could increase their original power from 100% to 101.5%, leaving the .5% as an uncertainty margin between 101.5% and 102%.

If plants **did not apply for this uprate**, they could do two other things per SE of TR CENPD 397, Rev. 01-P:

1) Apply the reduced instrument uncertainty to gain benefits other that power uprate, i.e., run closer to their license power rating.

2) Have the in-plant capability to periodically recalibrate the feedwater venturi due to the effects of fouling.