



This Presentation Consists of Three Separate Presentations:

- **MAAP4 Calculations for the Maanshan Station Blackout**
- **Hand Calculation: TMLB for a 4-Loop PWR**
- **Lessons Learned from These Evaluations**



MAAP4 Calculations for the Maanshan Station Blackout

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NRC**

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OUTLINE

- **Overview of Maanshan plant and SBO event**
- **MAAP4 simulations**
- **Comparison of MAAP4 results with plant data and MELCOR results (performed by INER of Taiwan)**
- **Impact of Sensitivity parameters on SBO without recovery**
- **Conclusions**



Overview of Maanshan Plant and SBO Event

- **Maanshan plant:**
 - **Westinghouse 3-loop PWR with large dry containment.**
 - **100% full power: 2775 MW_{th}.**
- **Sequence of SBO event:**
 - **Reactor scram on March 17, 2001, 03:22 AM due to unstable transmission line.**
 - **Reactor was in hot standby conditions.**
 - **SBO (loss of off-site power + both A&B diesel generators failed) at t = 21.38 hour since the scram.**



Sequence of Events

	Time After SBO
SBO	0
Turbine-driven AFW pump starts	0.22 hours
Operator depressurized RCS via SG PORV	0.22 hours
Accumulator injection On	1.75 hours
5th DG successfully starts	2.15 hours



MAAP4 Simulation

- **MAAP 4.0.5 archive version is used.**
- **Simulation starts at the time of SBO (time corresponding to 21.38 hours after the reactor scrams).**
- **Initial conditions based on the plant data at 21.38 hours and decay heat based on ANSI-1979.**
- **SG pressures and feedwater flows are input as boundary conditions.**



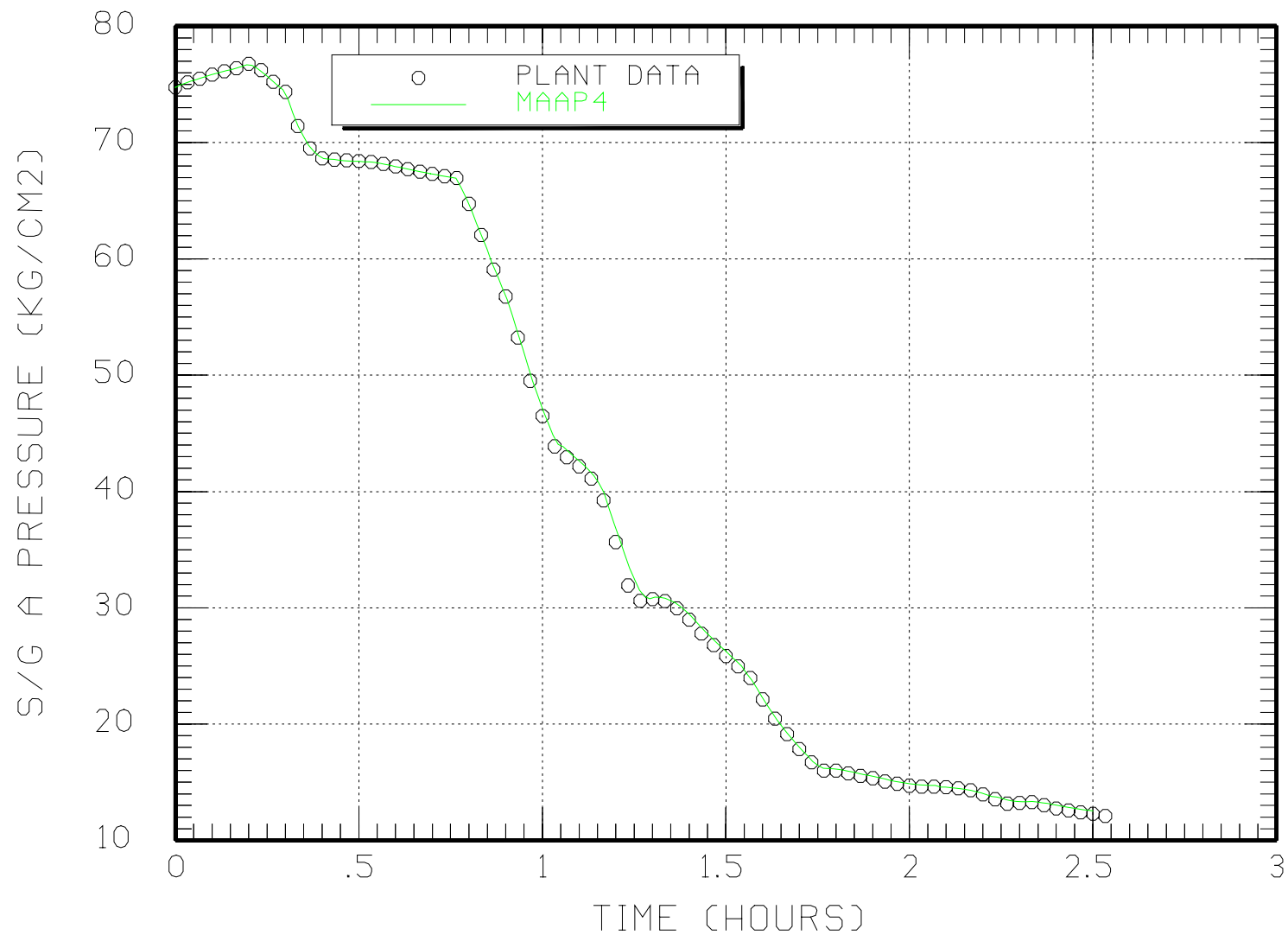
Three Cases (Base Case + 2 Sensitivity Cases)

- **Base case using default values on model parameters (HTSTAG is nominally 800 W/m²°C).**
- **Sensitivity Cases**
 - **Reduced the natural circulation steam generator primary side heat transfer coefficient when single- or two-phase natural circulation is occurring in the RCS loops (HTSTAG reduced to 400 W/m²°C – recommended sensitivity range from MAAP 3B application guide).**
 - **Mimic natural circulation using pump coast-down curve (SG primary side heat transfer coefficient is calculated using forced-convection heat transfer correlation).**



Base Case

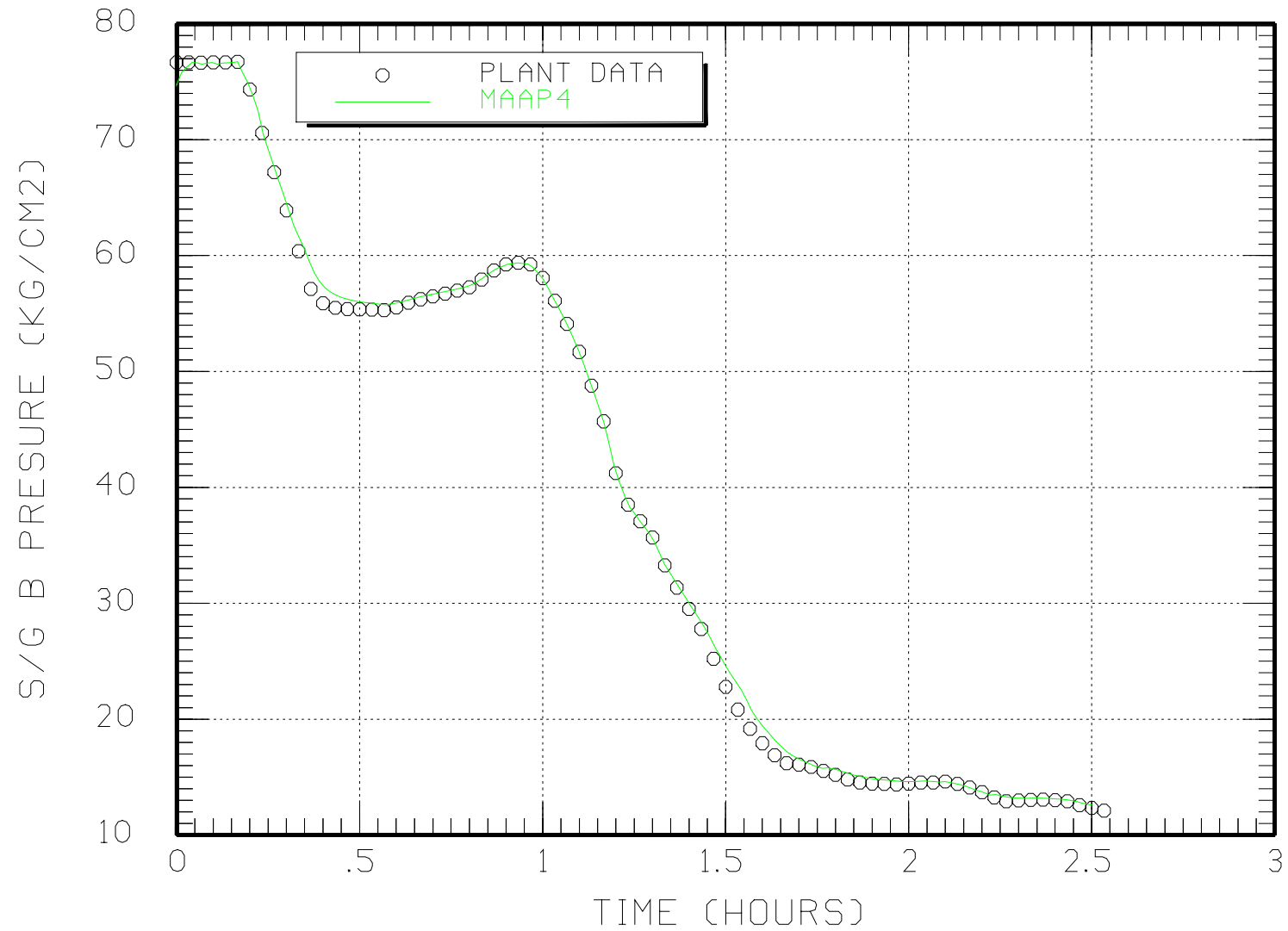
MAAP4 BASE CASE (HTSTAG=800 W/M²-C)





Base Case

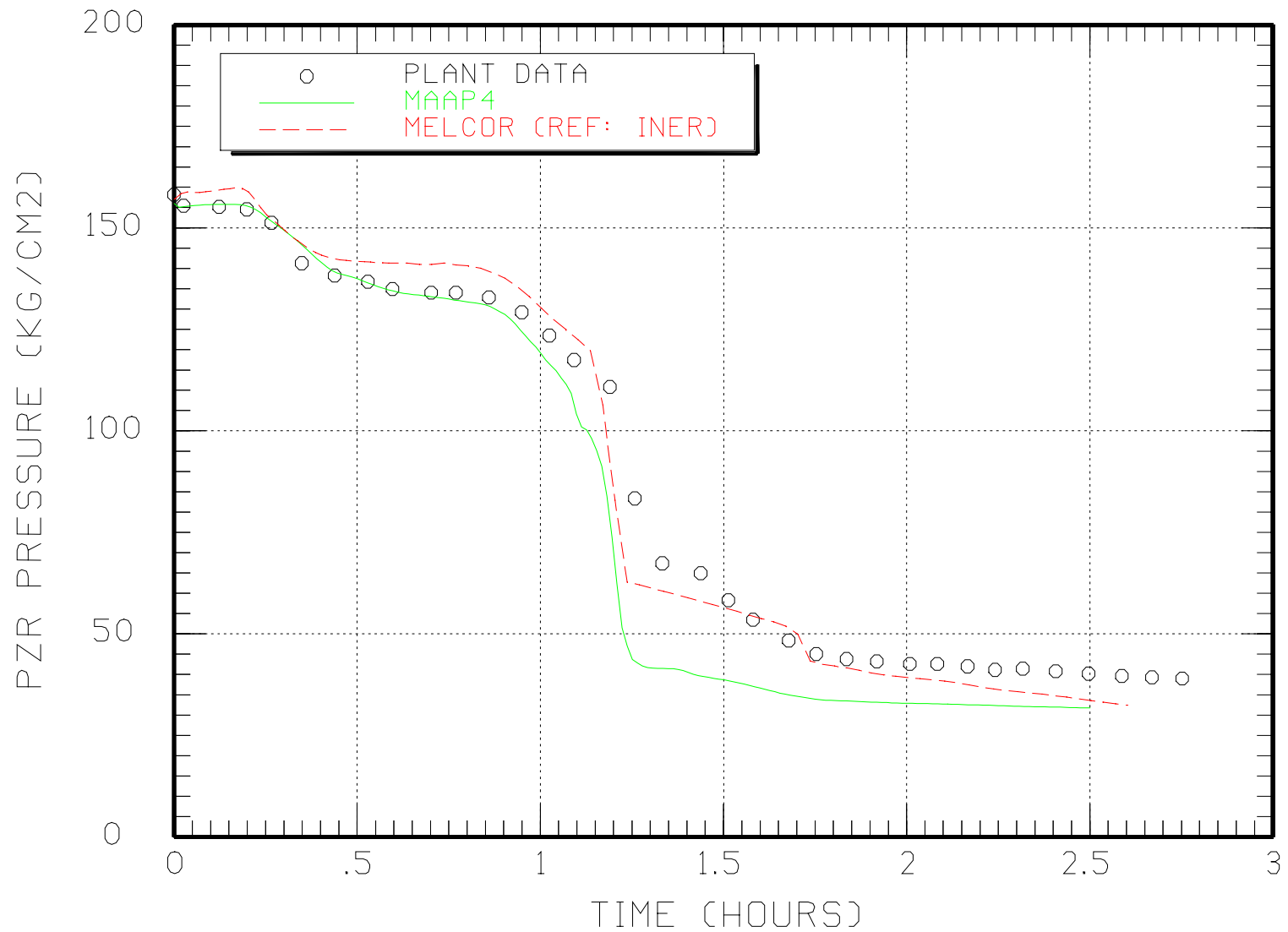
MAAP4 BASE CASE (HTSTAG=800 W/M2-C)





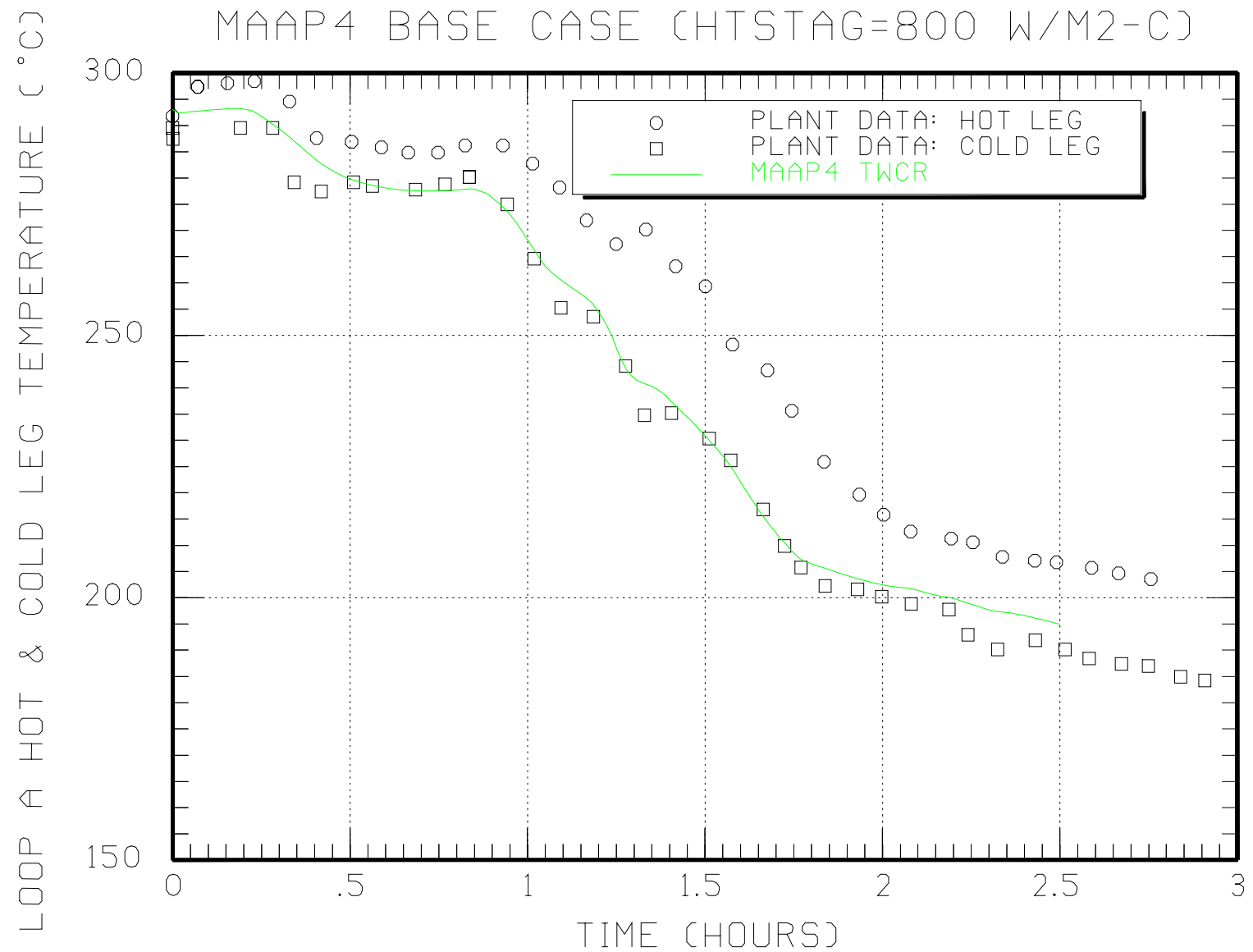
Base Case

MAAP4 BASE CASE (HTSTAG=800 W/M2-C)



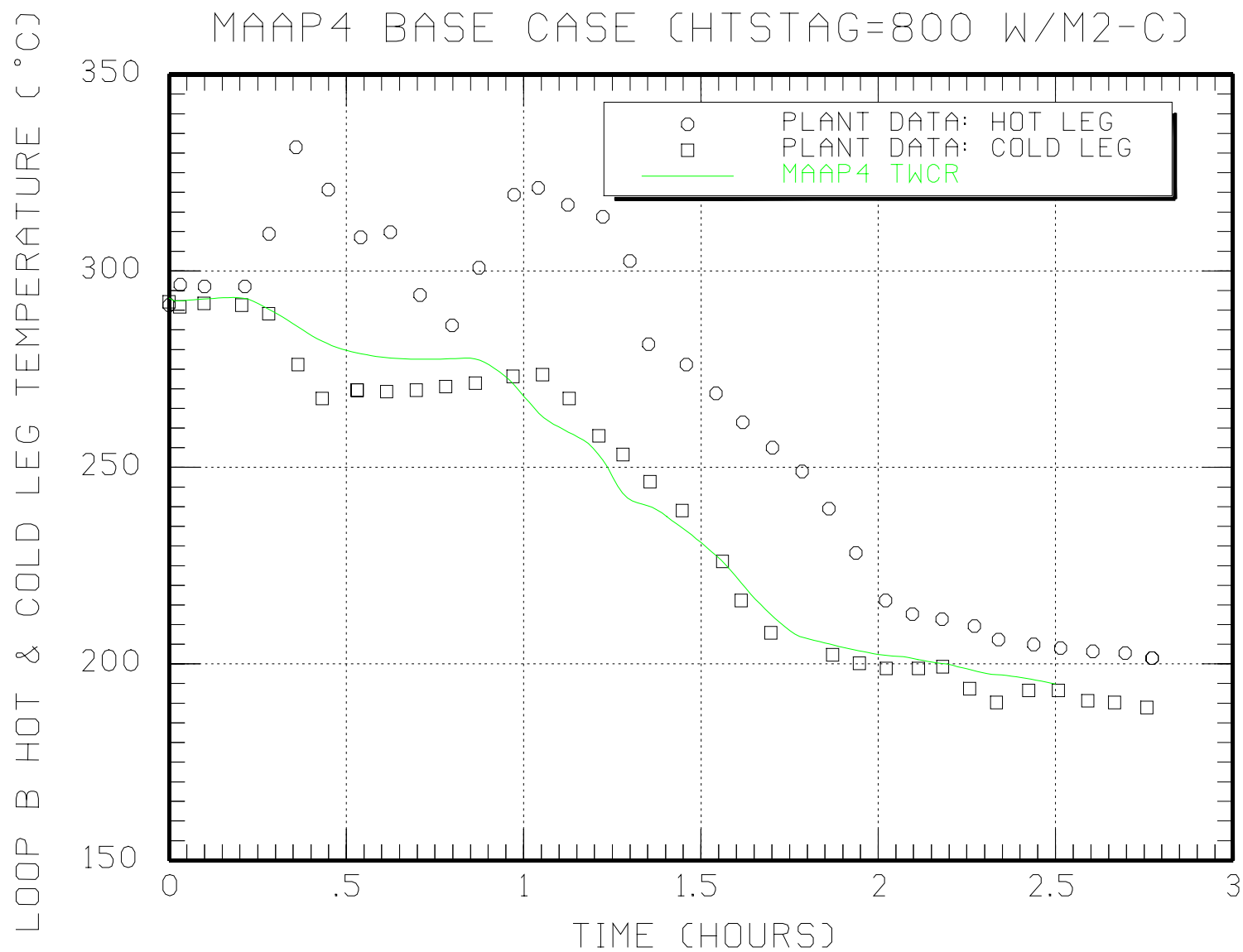


Base Case





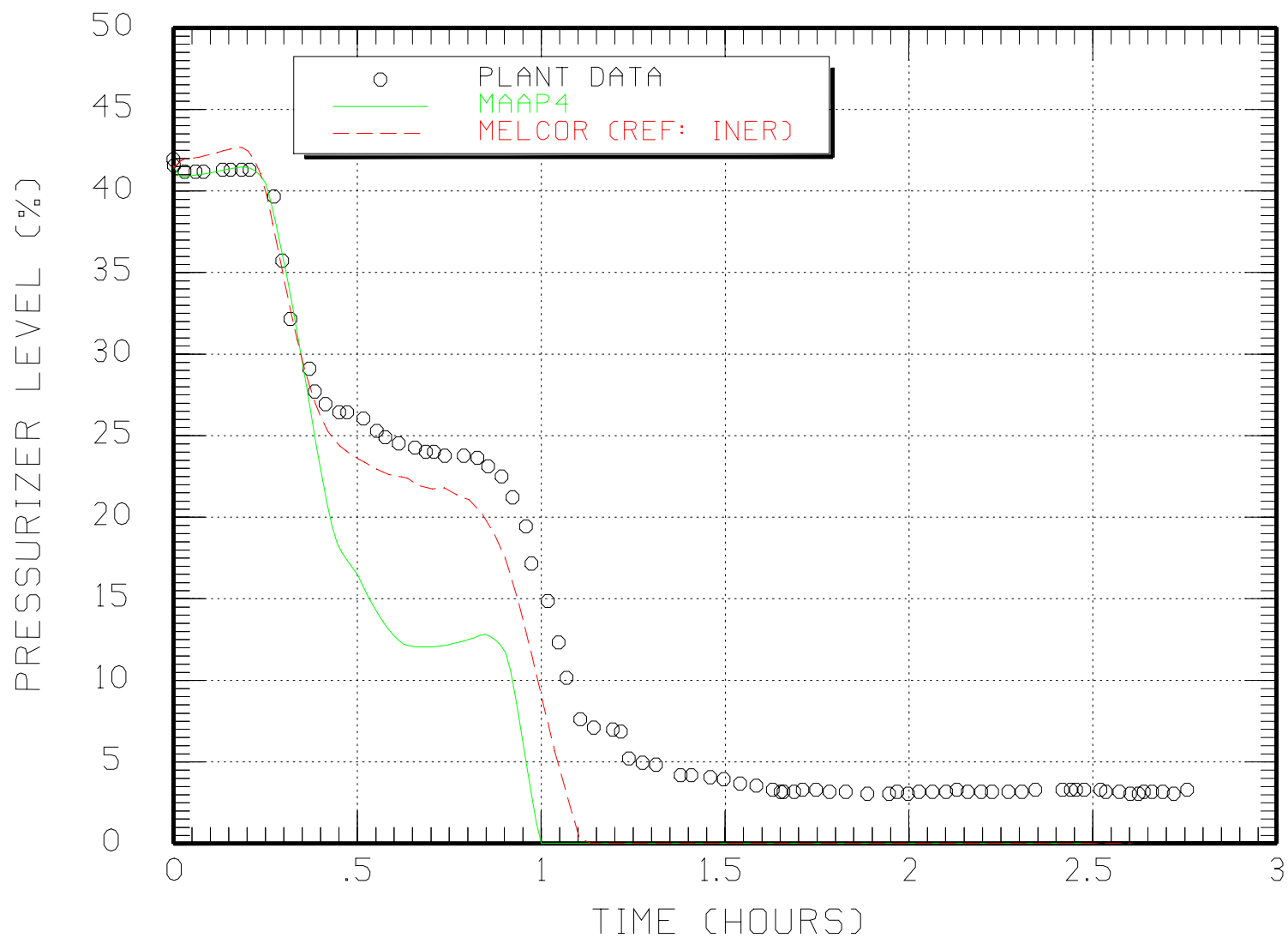
Base Case





Base Case

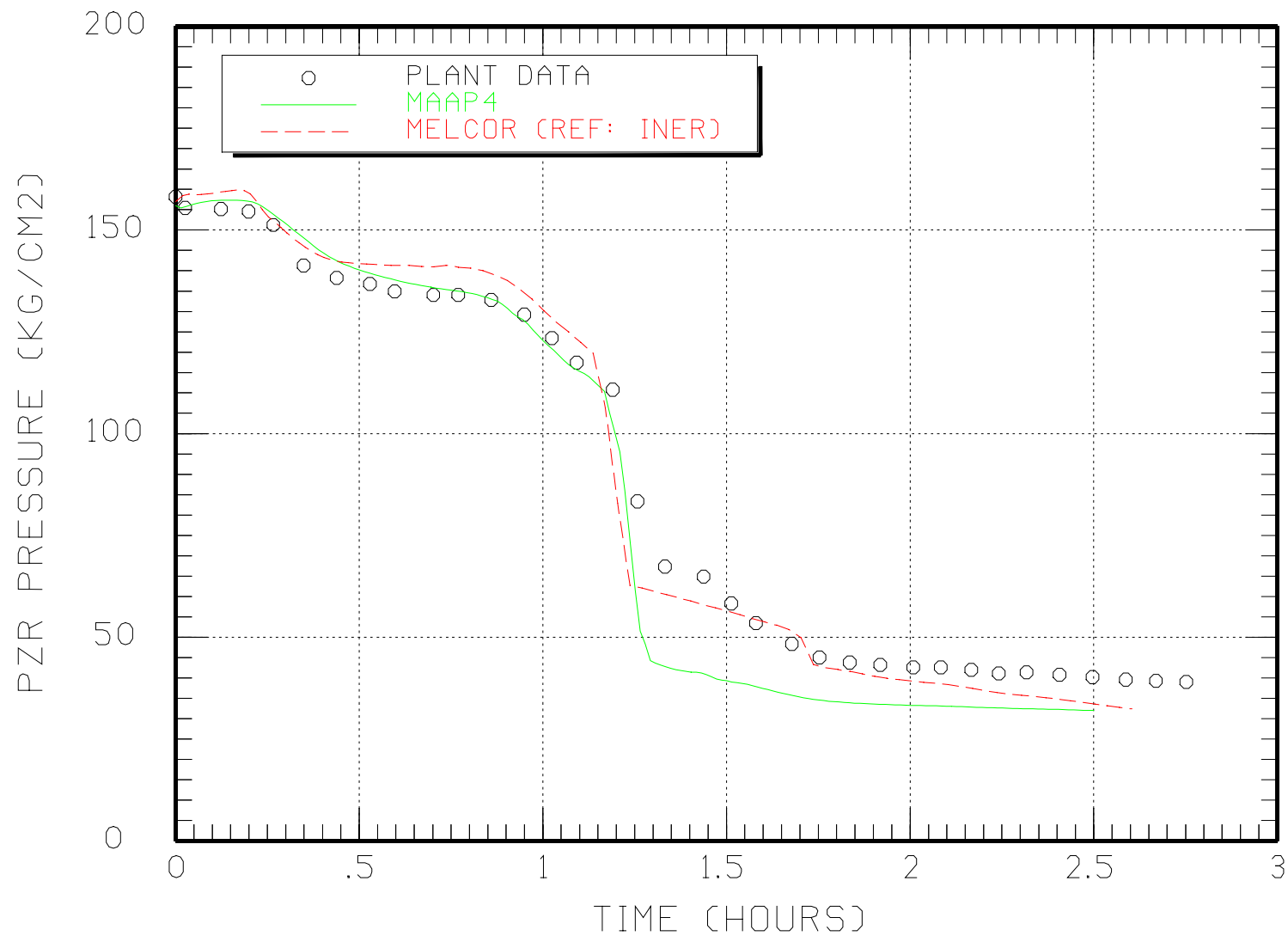
MAAP4 BASE CASE (HTSTAG=800 W/M2-C)





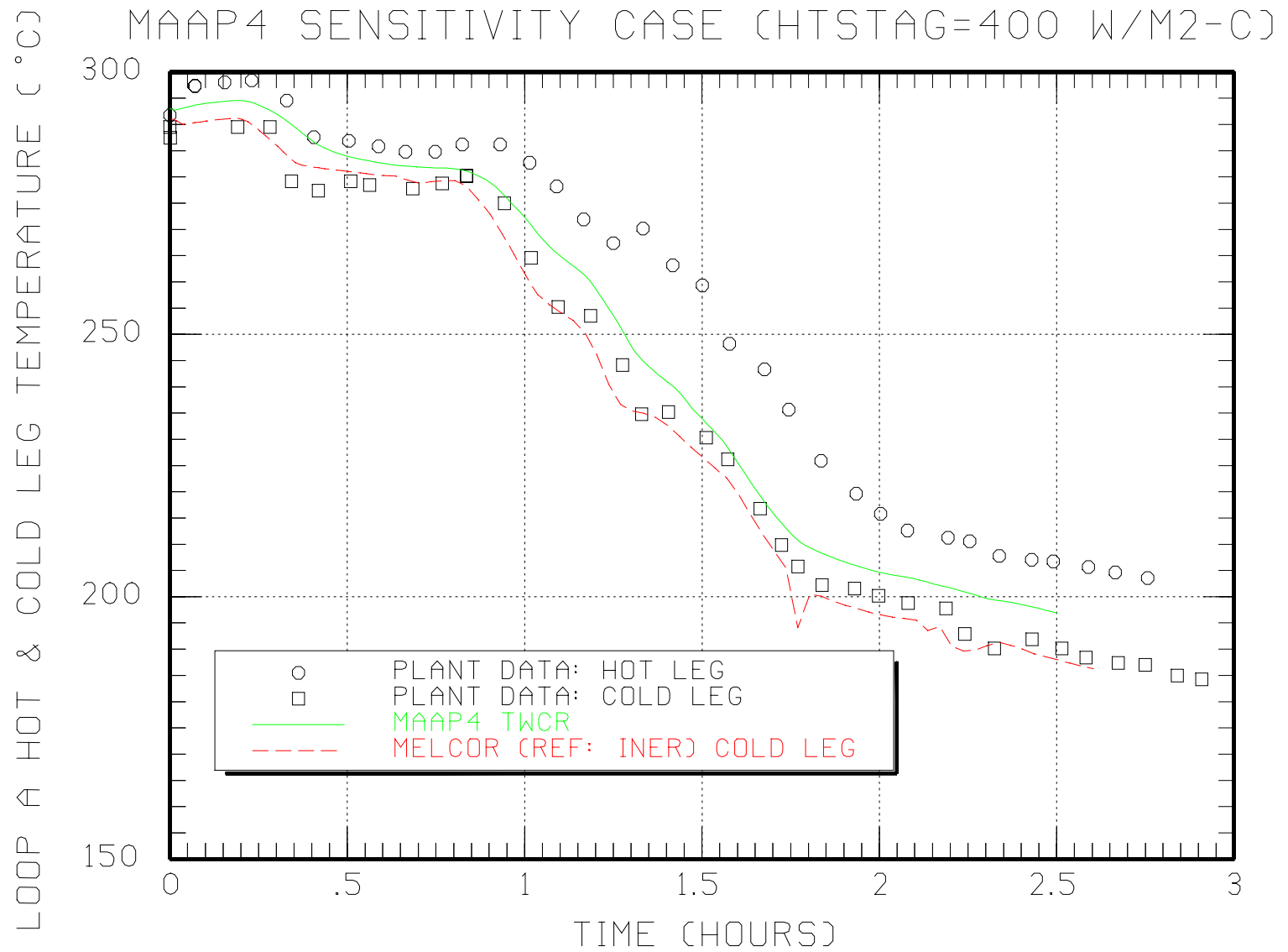
Sensitivity Case

MAAP4 SENSITIVITY CASE (HTSTAG=400 W/M²-C)



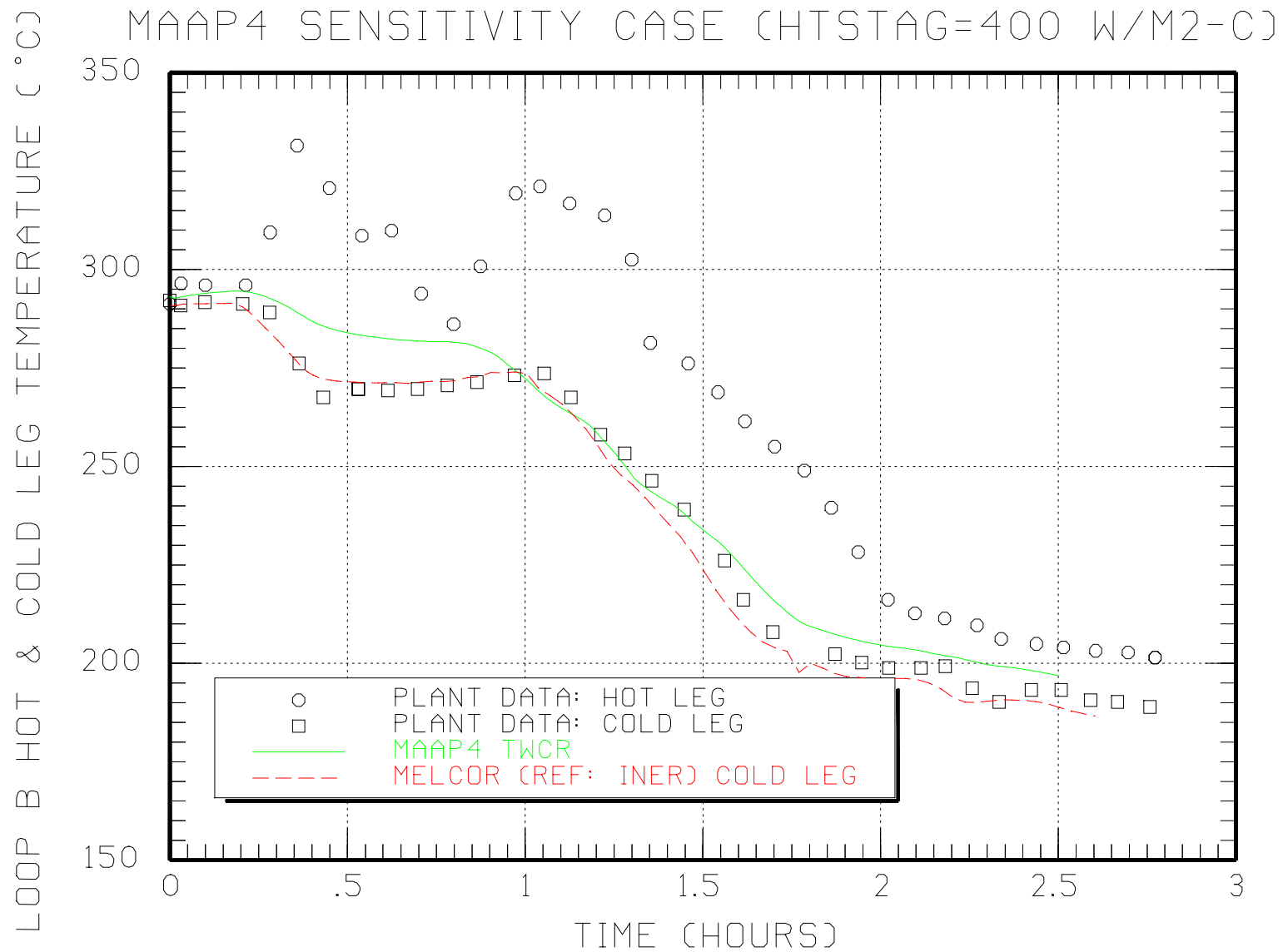


Sensitivity Case





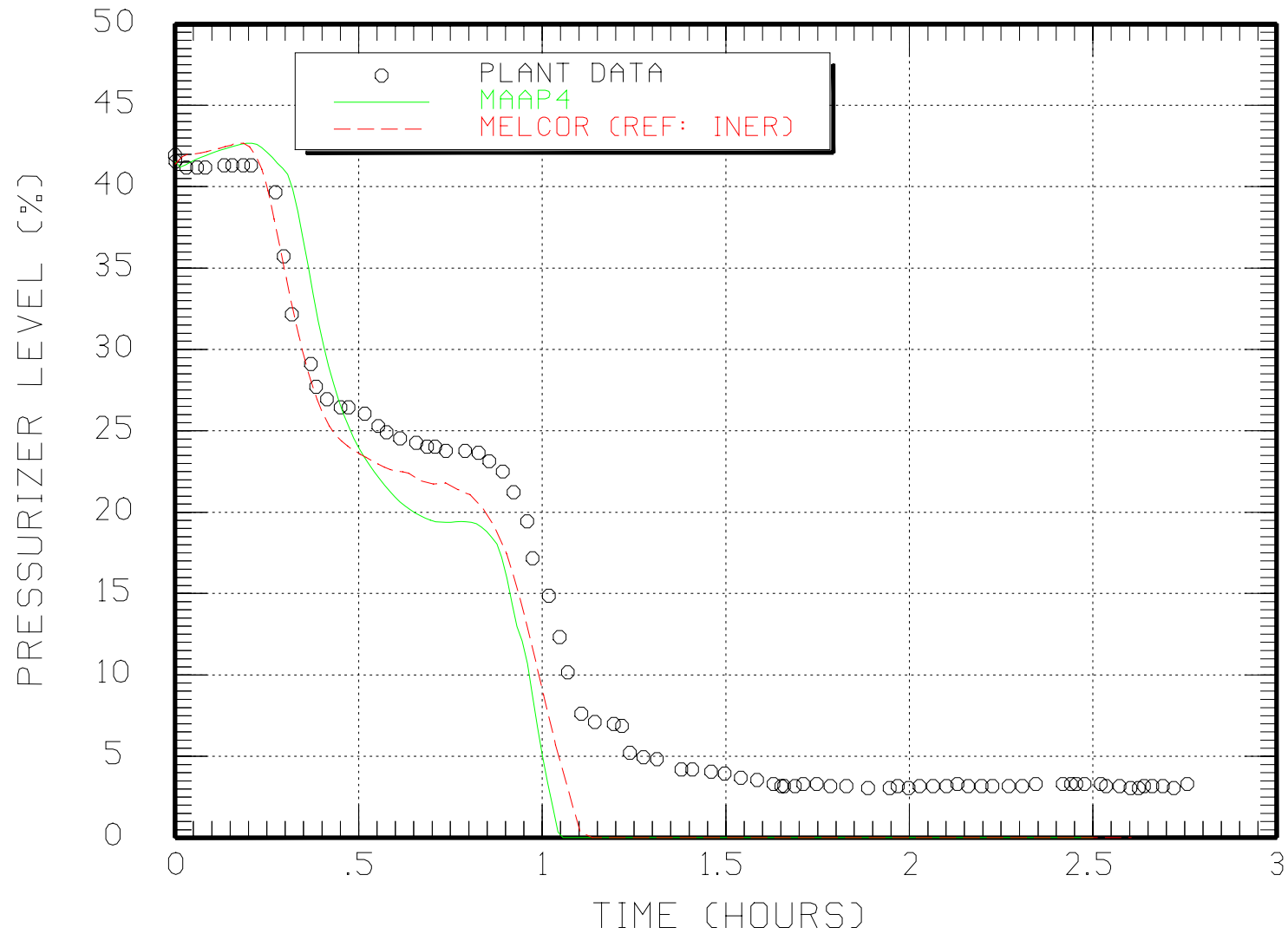
Sensitivity Case





Sensitivity Case

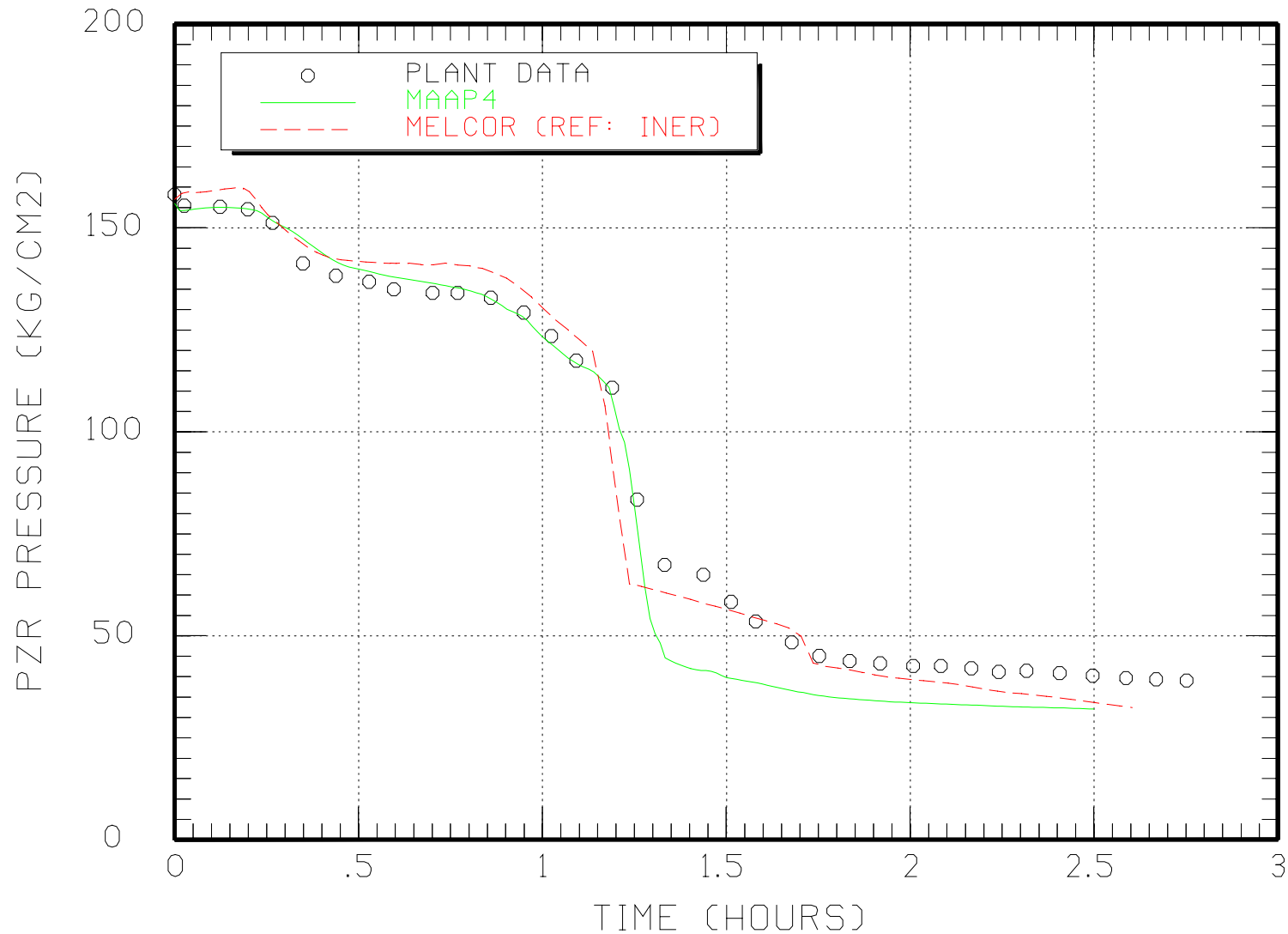
MAAP4 SENSITIVITY CASE (HTSTAG=400 W/M2-C)





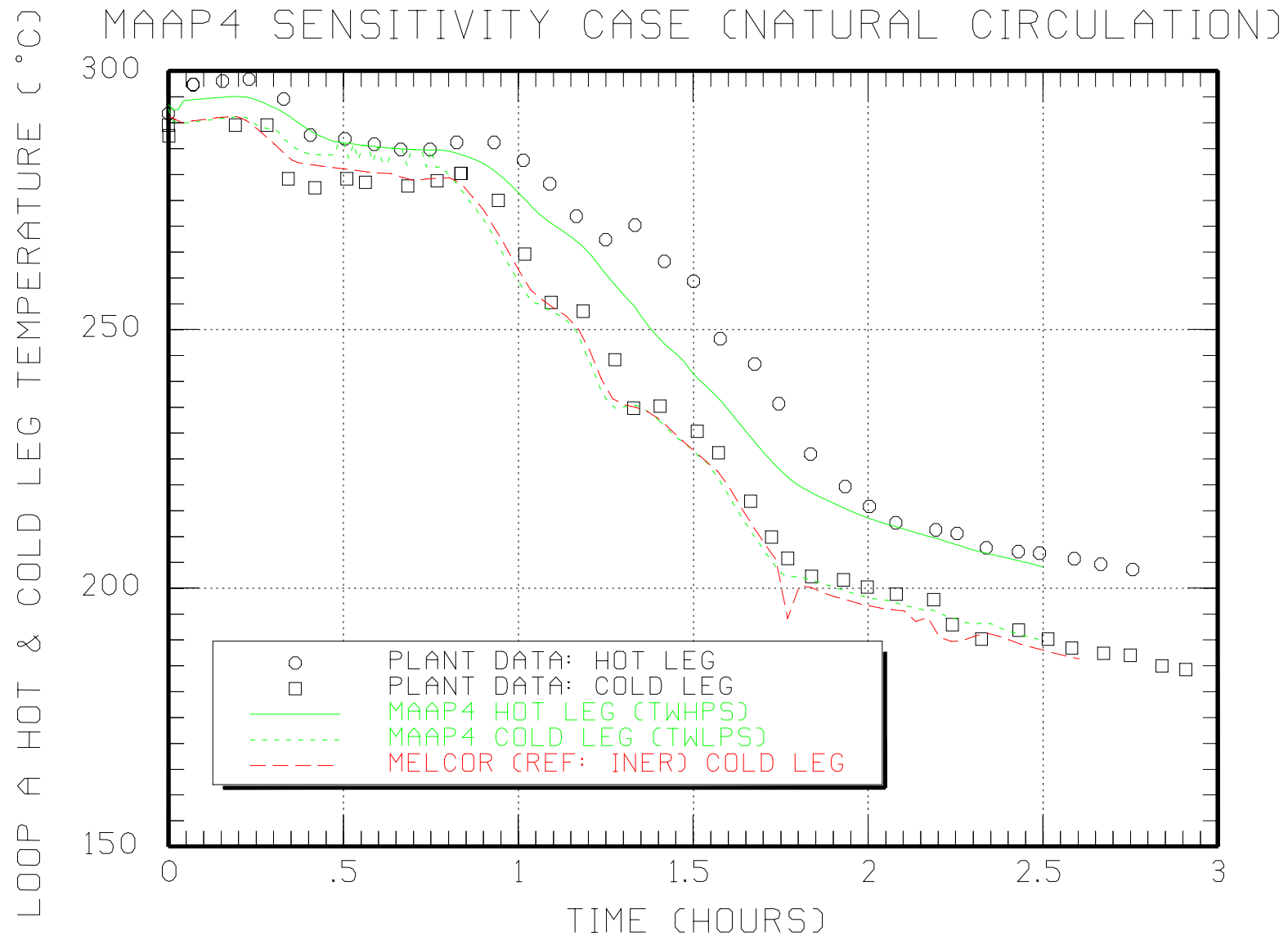
Sensitivity Case (Mimic Natural Circulation)

MAAP4 SENSITIVITY CASE (NATURAL CIRCULATION)



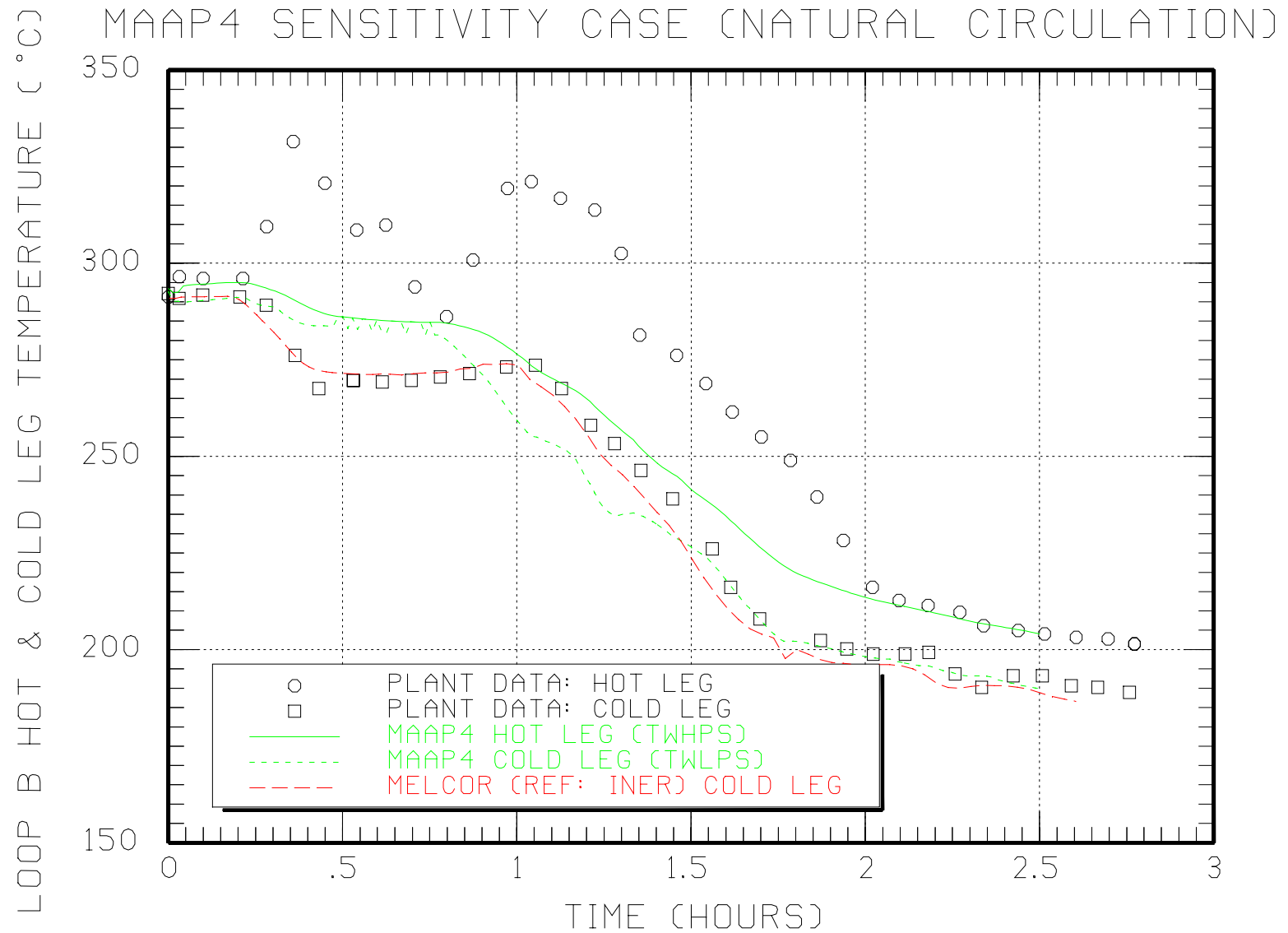


Sensitivity Case (Mimic Natural Circulation)



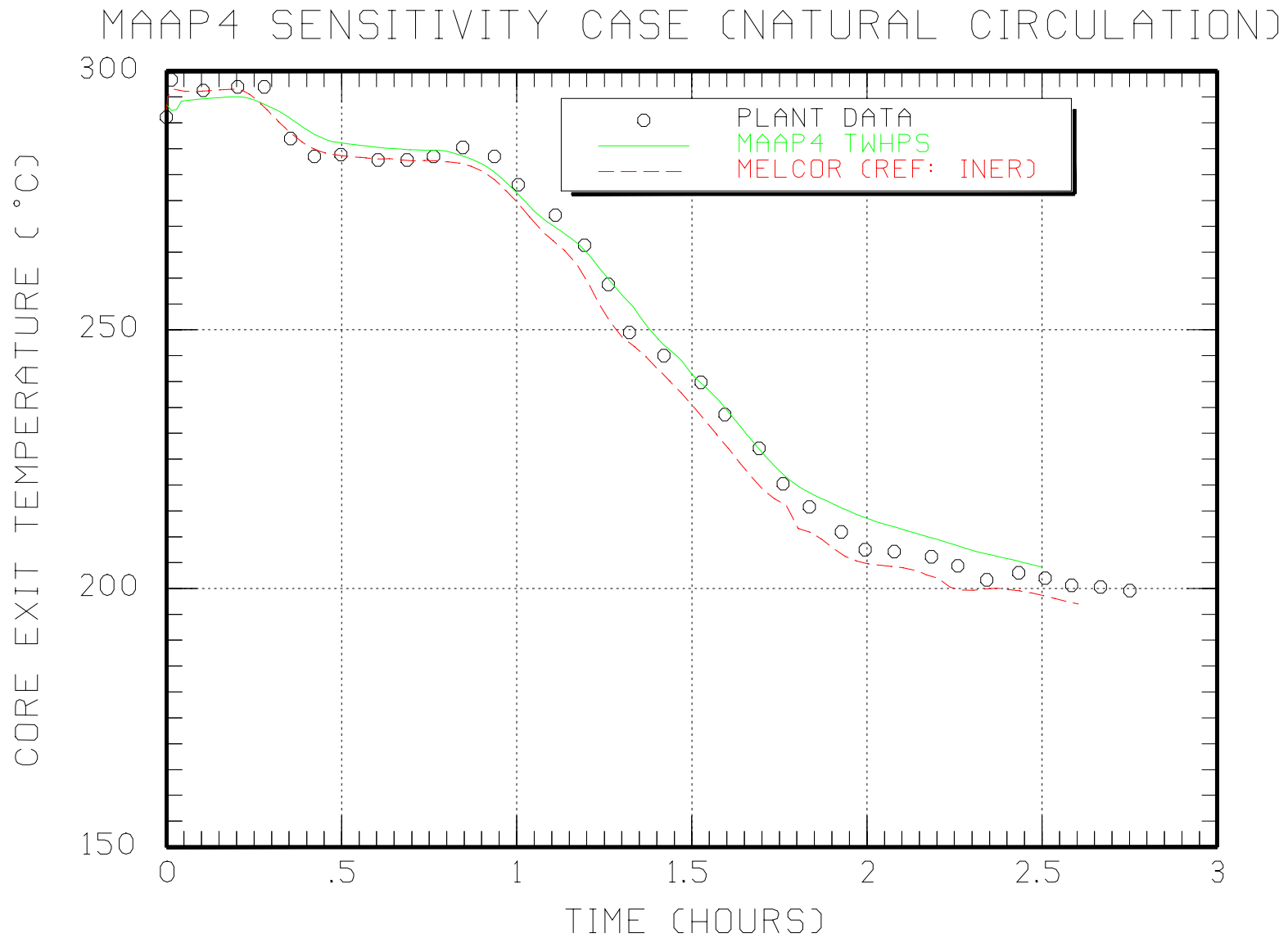


Sensitivity Case (Mimic Natural Circulation)





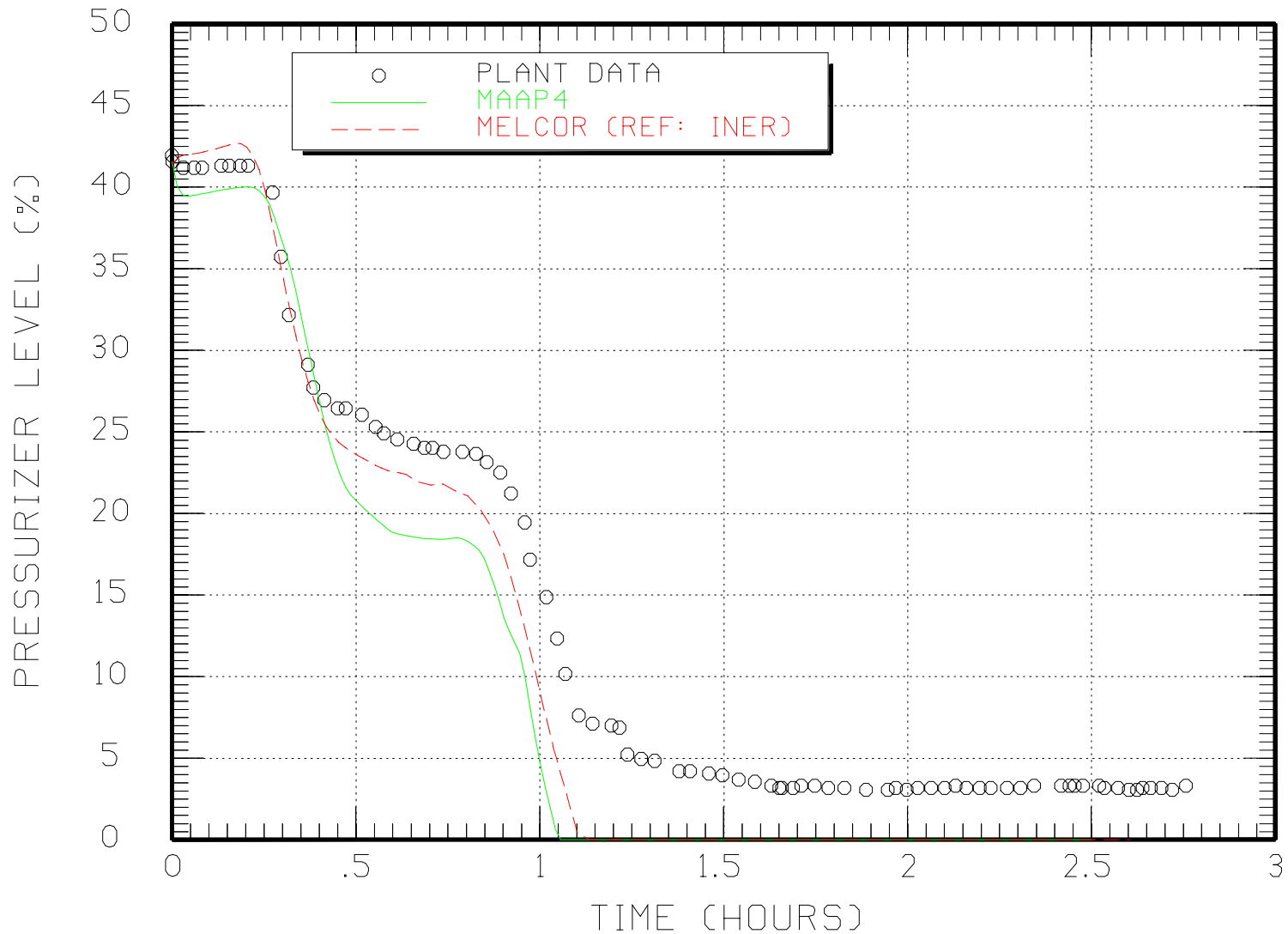
Sensitivity Case (Mimic Natural Circulation)





Sensitivity Case (Mimic Natural Circulation)

MAAP4 SENSITIVITY CASE (NATURAL CIRCULATION)





Impact of Sensitivity Parameters on SBO Without Recovery

- **What if 5th DG failed?**
 - **Assume TD AFW pump stops at 8 hours.**
 - **Assume no seal leakage.**
 - **Core will be uncovered after $\sim 97,500$ s.**
 - **Largest difference is SG water inventory at 8 hours.**

	Time when two-phase level is at the top of active fuel	Collapsed Level @ TAF
Base Case (HTSTAG = $800 \text{ W/m}^2\text{°C}$)	97,513 s	97,328
HTSTAG = $400 \text{ W/m}^2\text{°C}$	98,150 s	97,963
Mimic natural circulation	98,473 s	98,280



Impact of Sensitivity Parameters on SBO Without Recovery

- **What if TDAFW pump and 5th DG not available?**
 - **No TDAFW available from time 0.**
 - **Assume no seal leakage.**
 - **No RCS depressurization through SG PORV.**
 - **Core will be uncovered after $\sim 32,000$ s.**

	Time when two-phase level is at the top of active fuel	Collapsed Level @ TAF
Base Case (HTSTAG = $800 \text{ W/m}^2\text{°C}$)	32,332 s	32,162
HTSTAG = $400 \text{ W/m}^2\text{°C}$	32,558 s	32,394
Mimic natural circulation	32,288 s	32,117



CONCLUSIONS

- **MAAP4 results generally agree with the plant data for the SBO sequence.**
- **With adjustments of MAAP input parameters (sensitivity studies), comparisons with the details of the plant data can be improved. In this case, this is primarily a result of the low decay heat at $t=0$ (start = 21.38 hours).**
- **These sensitivity parameters have very little impact on overall time to when the core is uncovered.**