Methanol as a low cost alternative fuel for emission reduction in gas turbines

Joint Venture between IEC and Dor Chemicals

THE 11TH ISRAELI SYMPOSIUM ON JET ENGINES AND GAS TURBINES
Thursday, October 25, 2012 (9:00-17:00)

The Need for Methanol

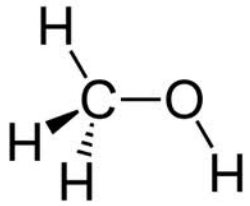
- **Dramatic increase in regulatory requirements for reduced emissions.**
- **Traditional methods of reducing NOx emissions, such as:**
  - **modification of the firing system (DLN – Dry Low NOx)**
  - **injection of water into the firing system (WLN – Wet Low NOx)**
  - **post combustion treatment of the flue gas to remove NOx (such as SCR – Selective Catalitic Reduction)**

All are very expensive!

Low cost alternatives should be checked!

Methanol as an Option

Methanol is a synthetic alcohol



Properties:

- Chemical Formula CH3OH
- Molecular weight 32.04
- Flash point 12 C (to 41 C)
- Auto-ignition temperature 464 C
- Combustion (Adiabatic) temperature 2045 C
- **Low heating value 4777 kcal/kg**
- Density 793 kg/ M^3 at 30 C

Methanol is Attractive Option

Methanol can achieve:

- Reduced NOx emissions - lower flame temperature and no Fuel-Bound Nitrogen (FBN)
- No SO2 emissions - has no sulfur
- Clean heat surfaces and lower maintenance - clean burning characteristics of methanol (better than with HFO or even with LFO)
- Higher power output relative to NG and FO - higher mass flow in GT engines

Methanol Firing at FT4C TWIN PAC 50 MW GT Unit

Two stage tests:

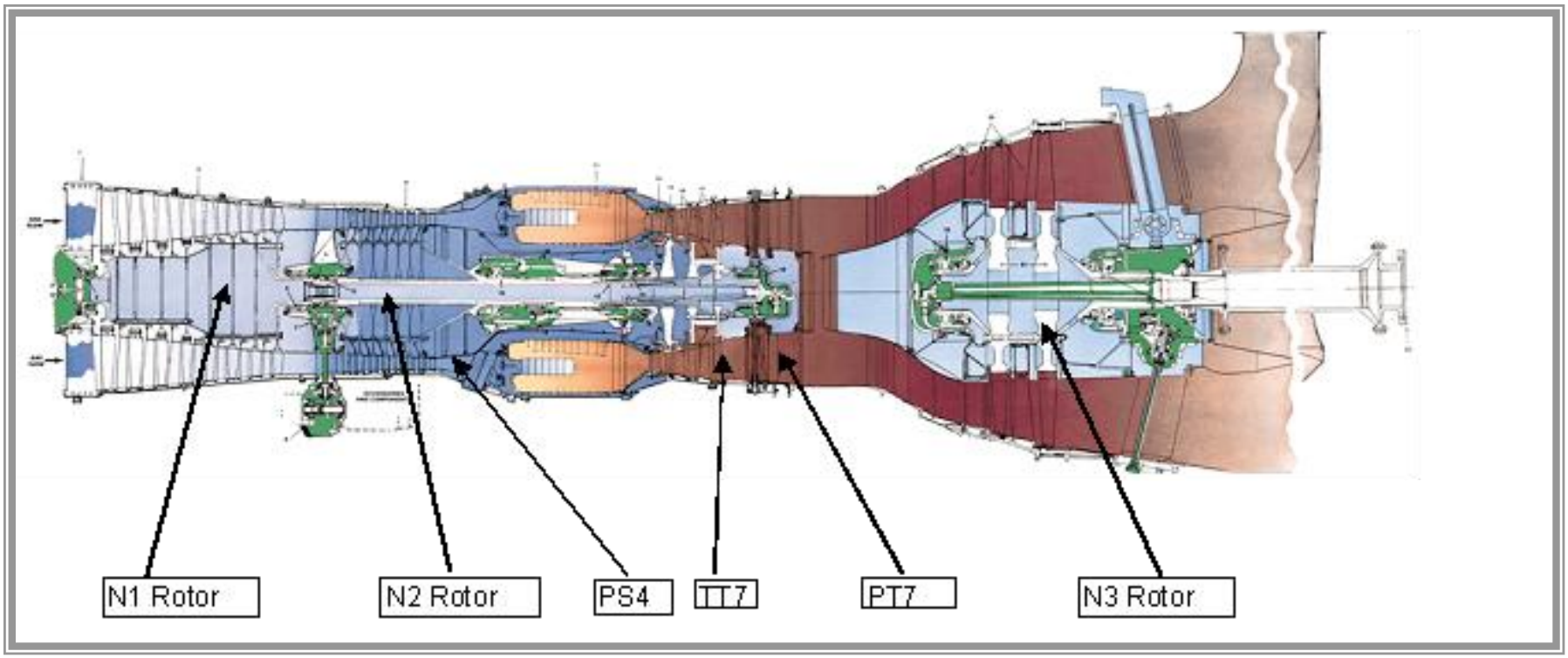
1 – to prove feasibility (Caesarea)

2 – to restore capacity and gain operational experience (Eilat)

Caesarea Power Plant Site

TP -1 Base Plate Assembly

FT4 – Engine & Power Turbine



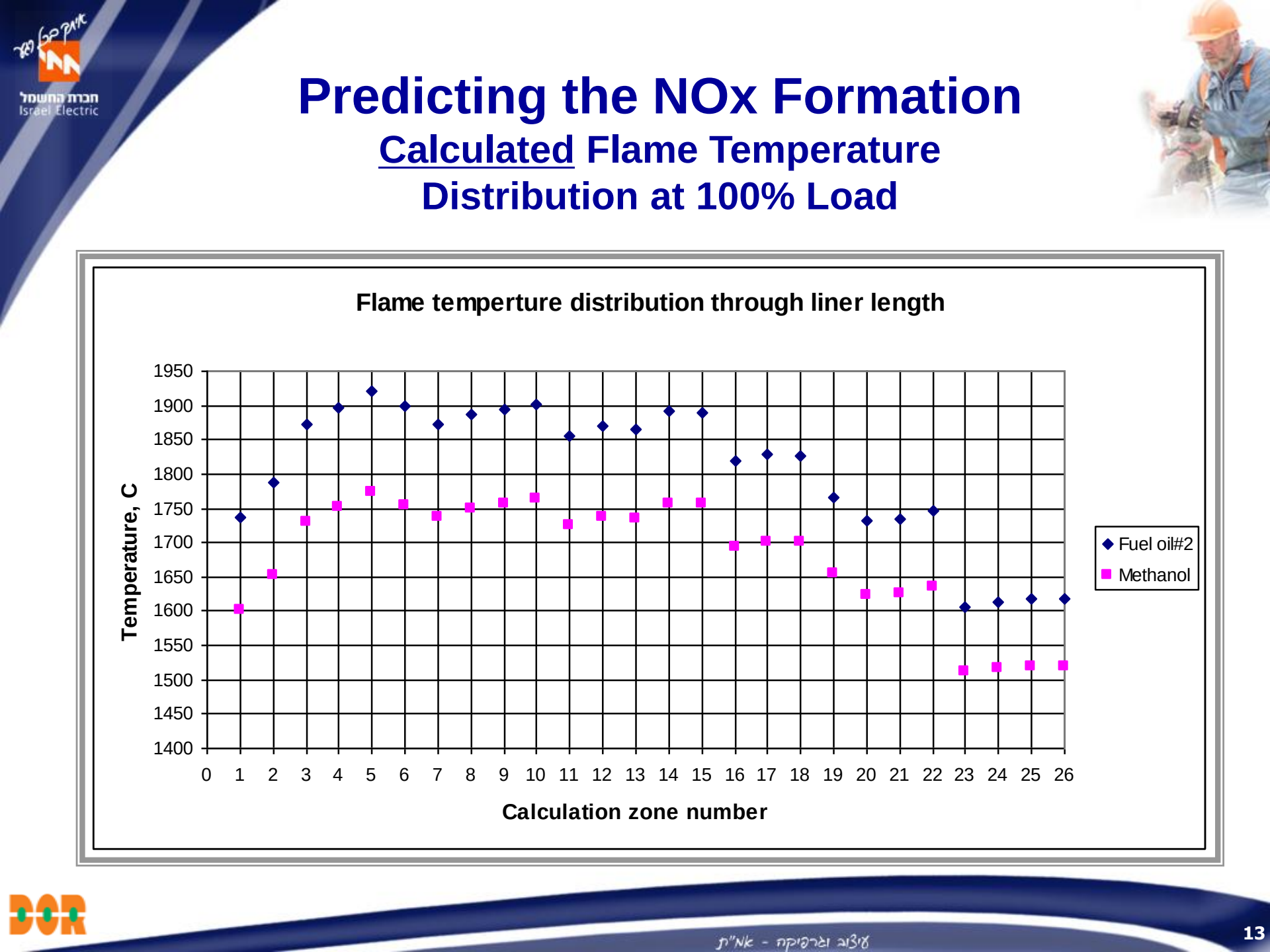
Liner

Fuel Spraying Nozzles

FO Atomizer Assembly

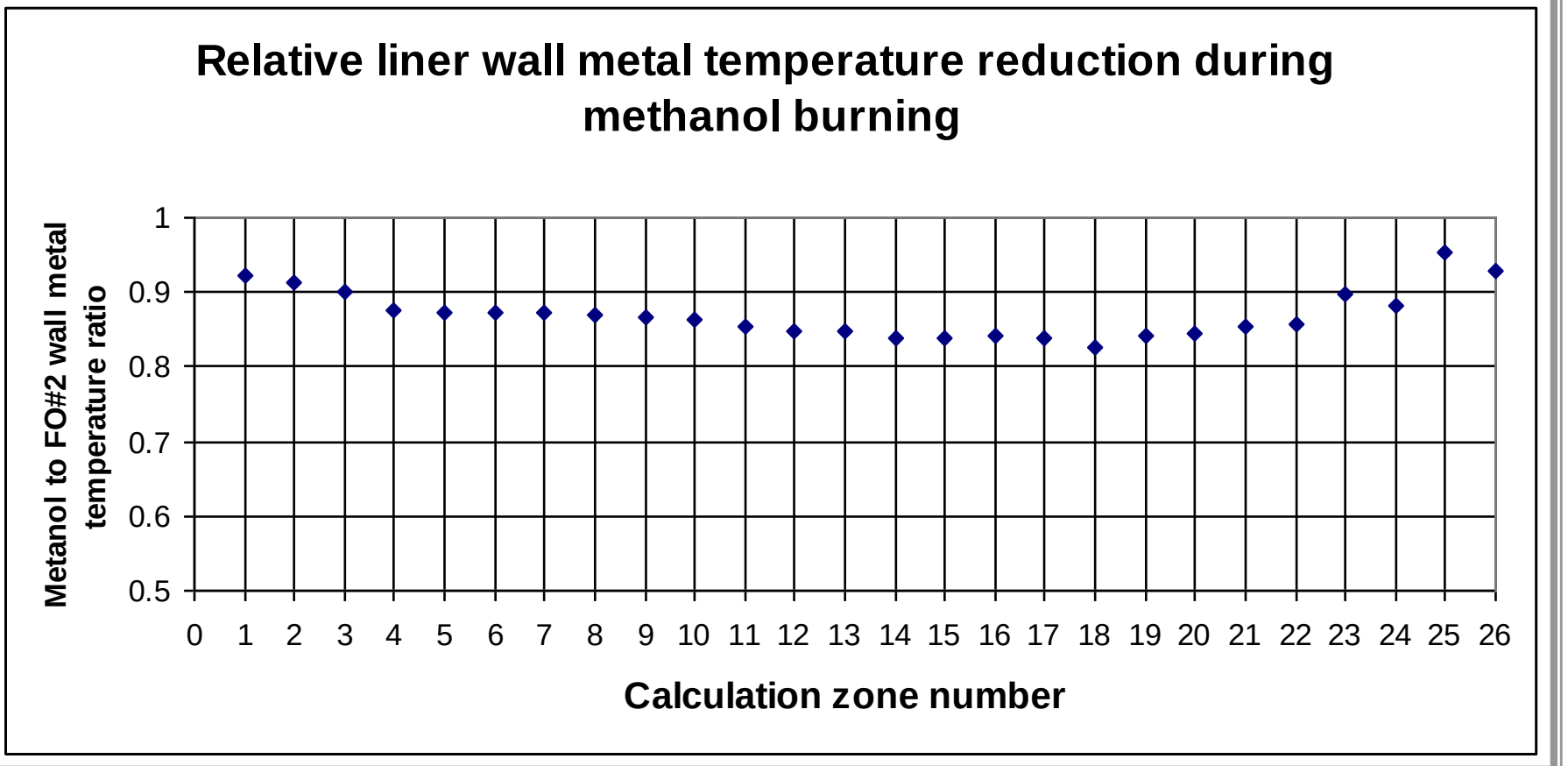
Predicting the NOx Formation

Calculated Flame Temperature Distribution at 100% Load



Predicting the NOx Formation

Calculated Liner Wall Temperature Distribution at 100% Load



Predicting the NOx Formation

Comparison of Calculated NOx Formation Through Liner Length for FO#2 and for Methanol Firing at 100% Load

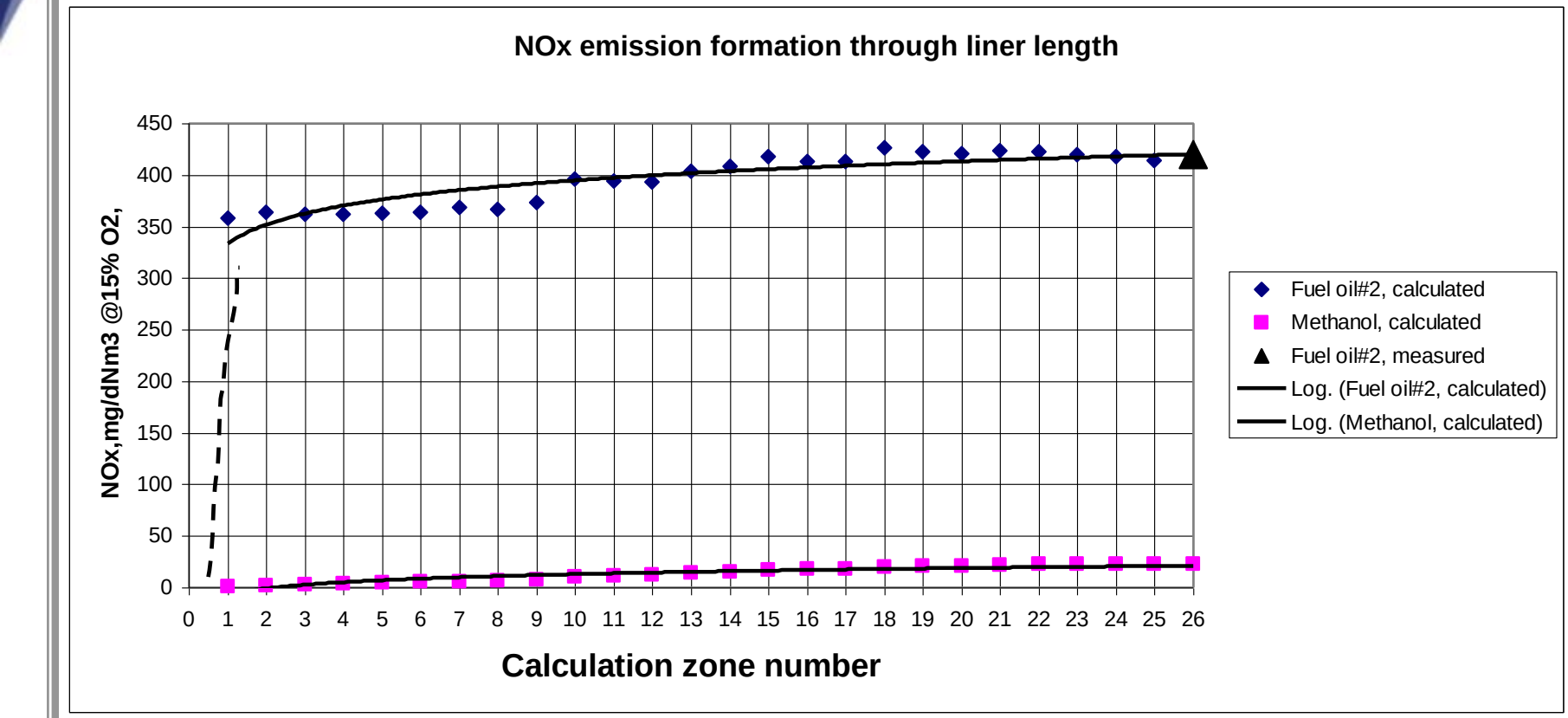
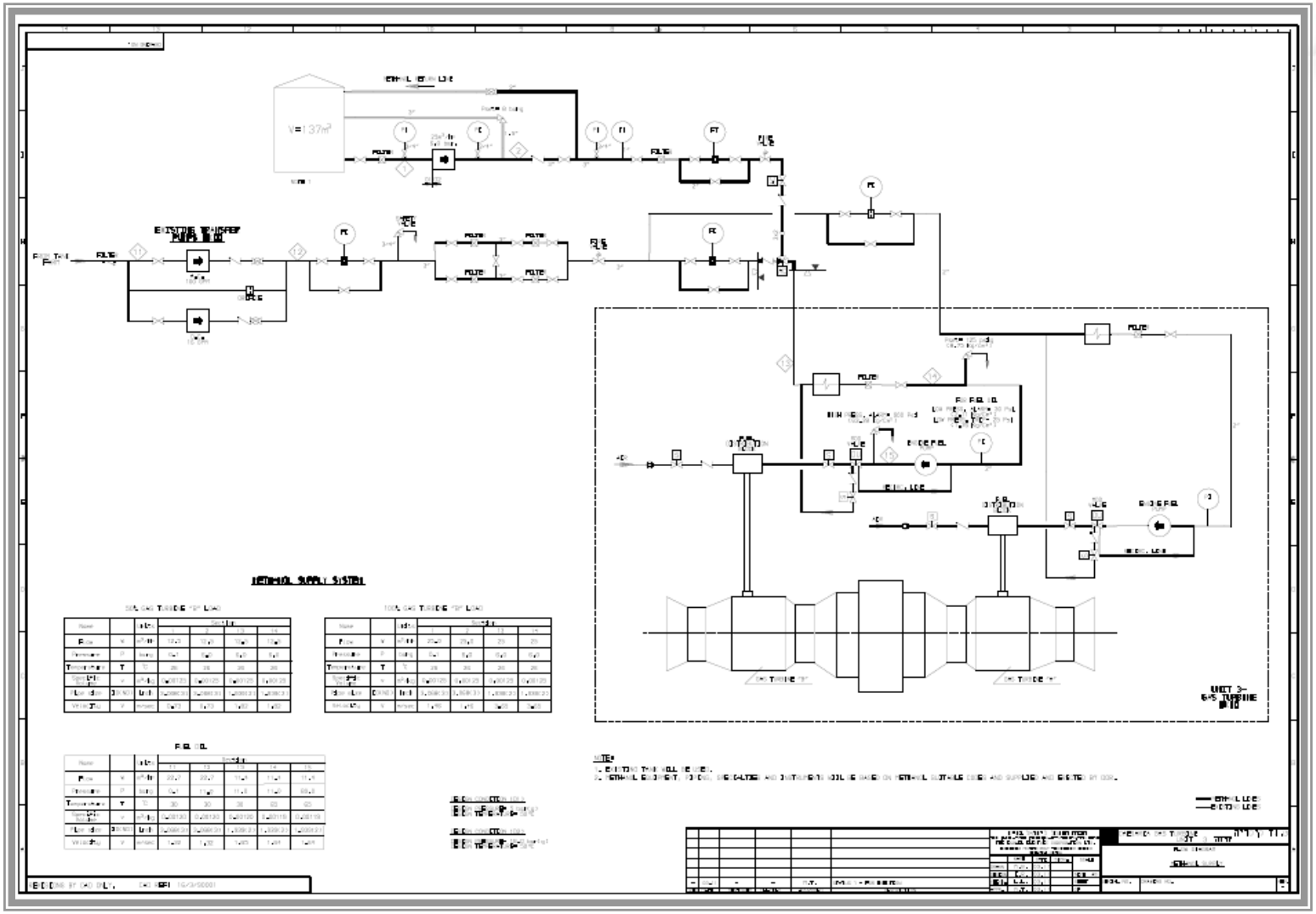


Diagram for Methanol Firing Test

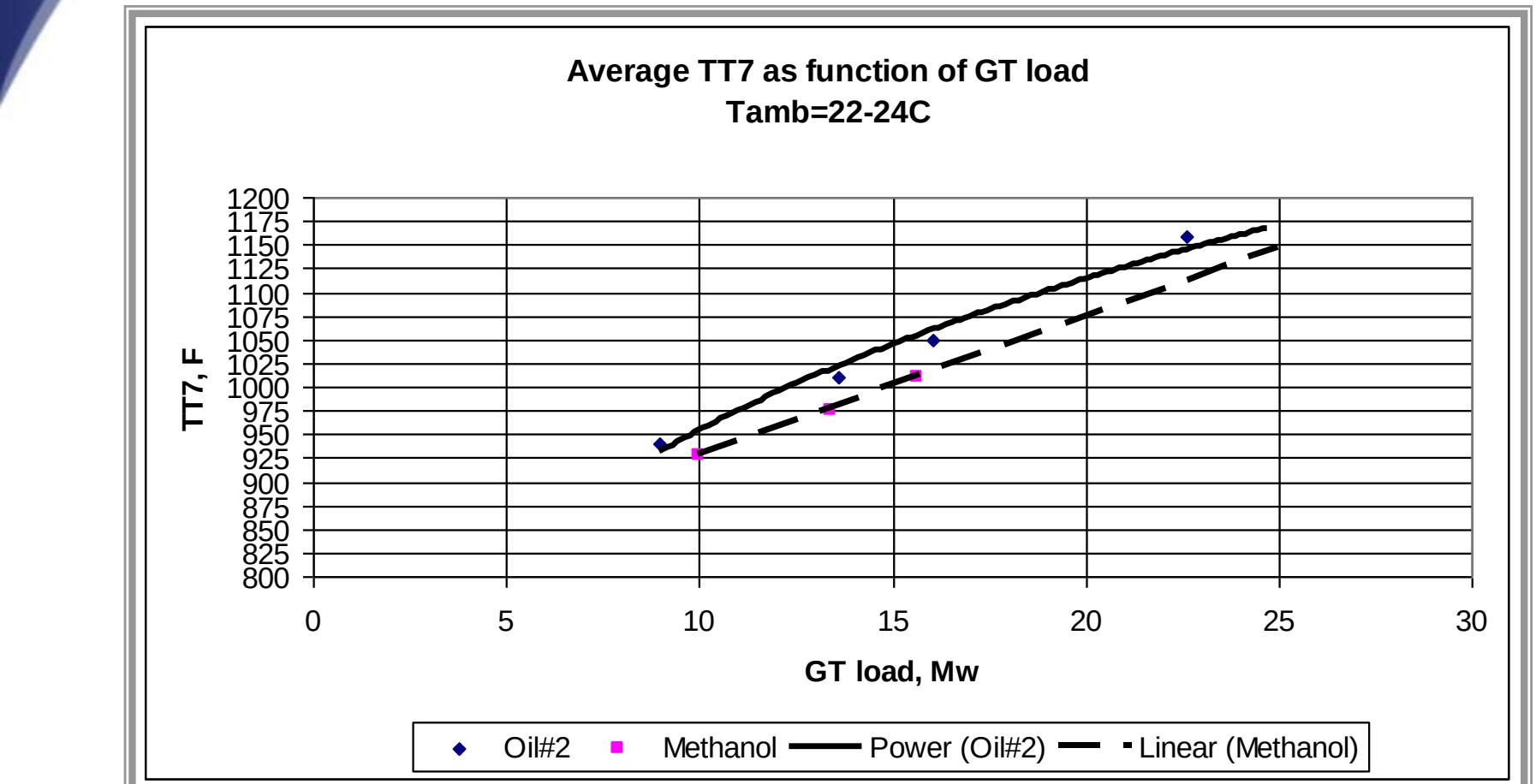


Methanol Tank With Dike

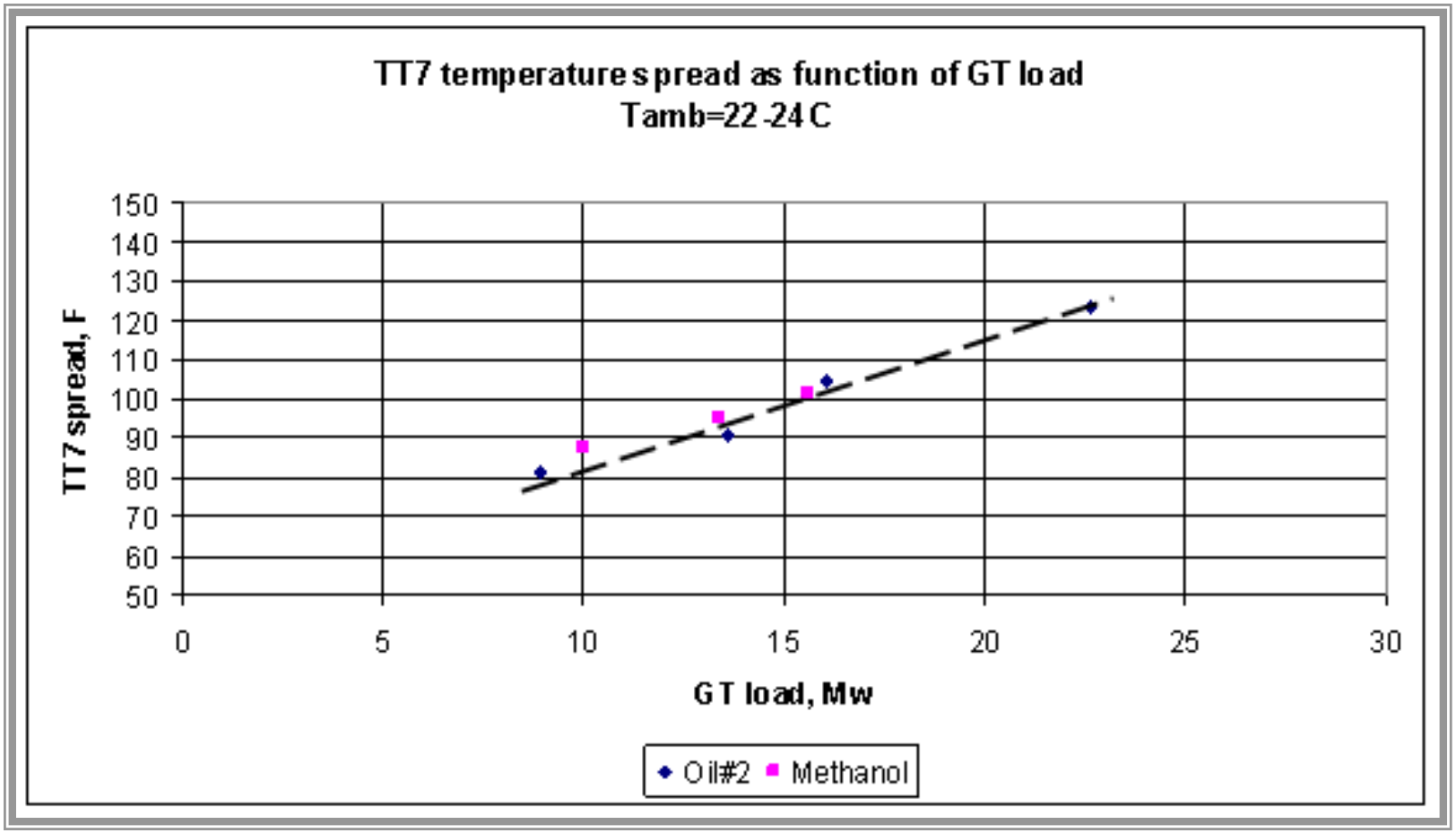
Methanol Connection Junction

Emission Measurements Instruments

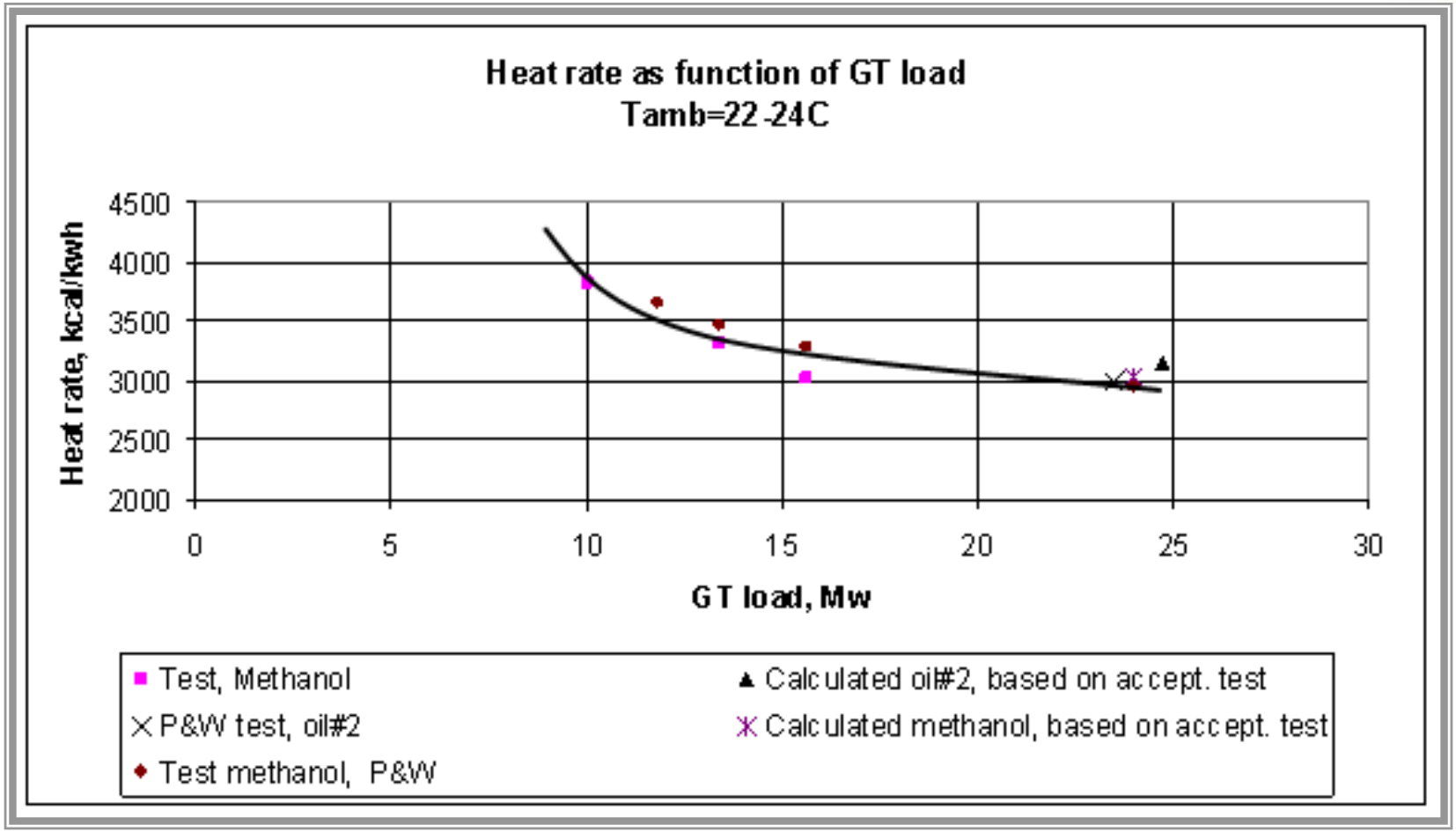
Test Results
TT7



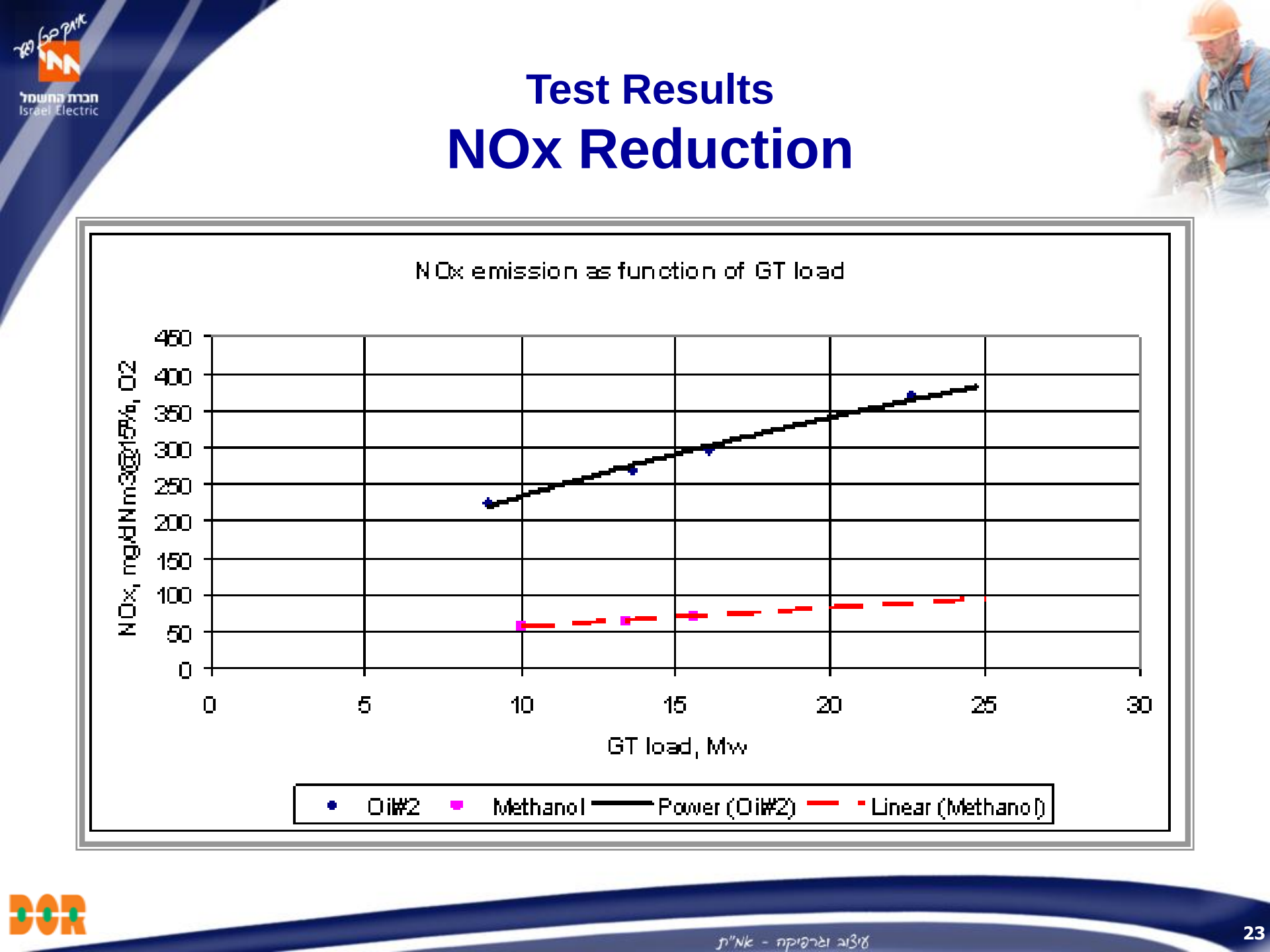
Test Results
Temperature Spread



Test Results
Heat Rate

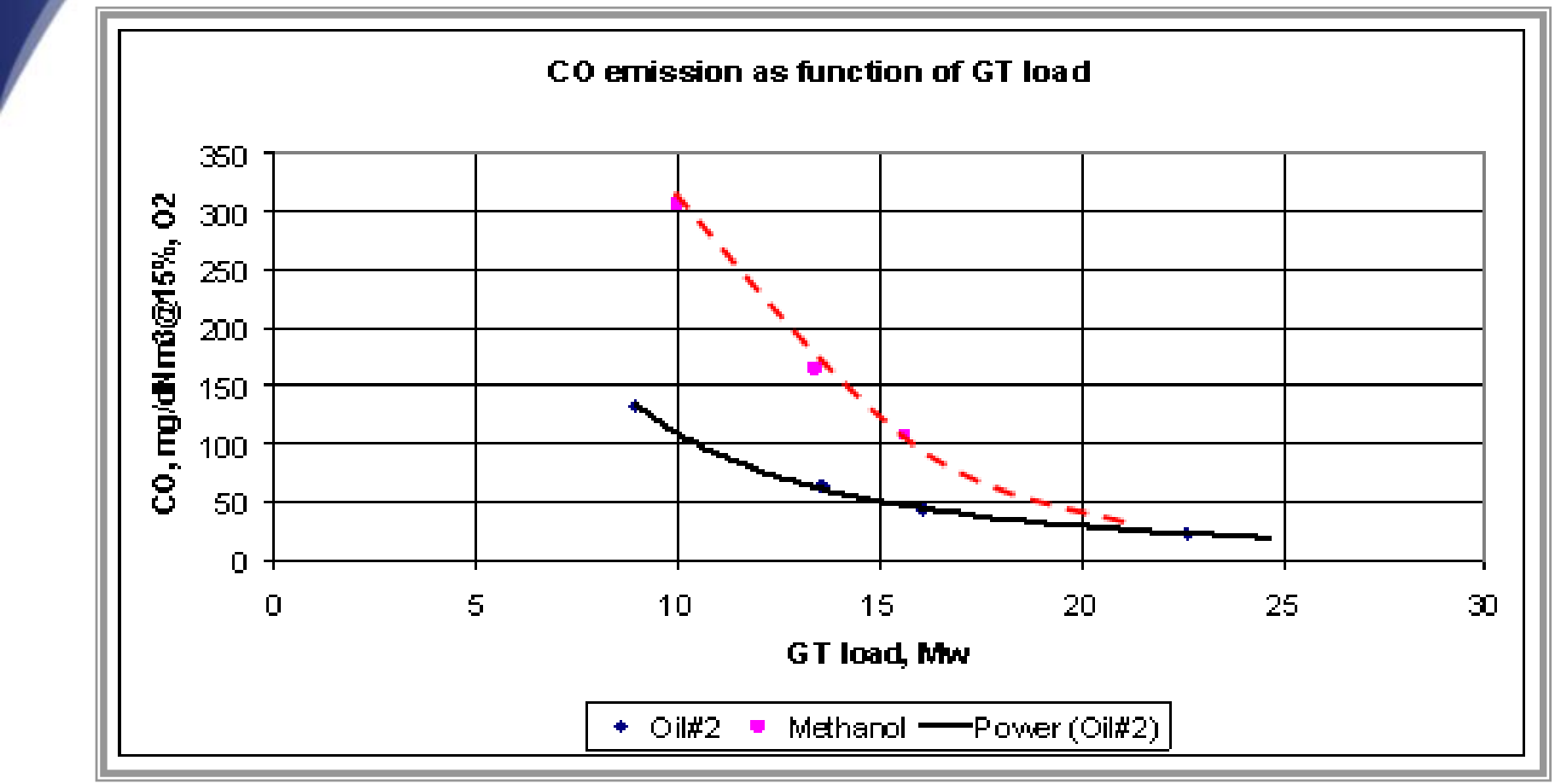


Test Results
NOx Reduction



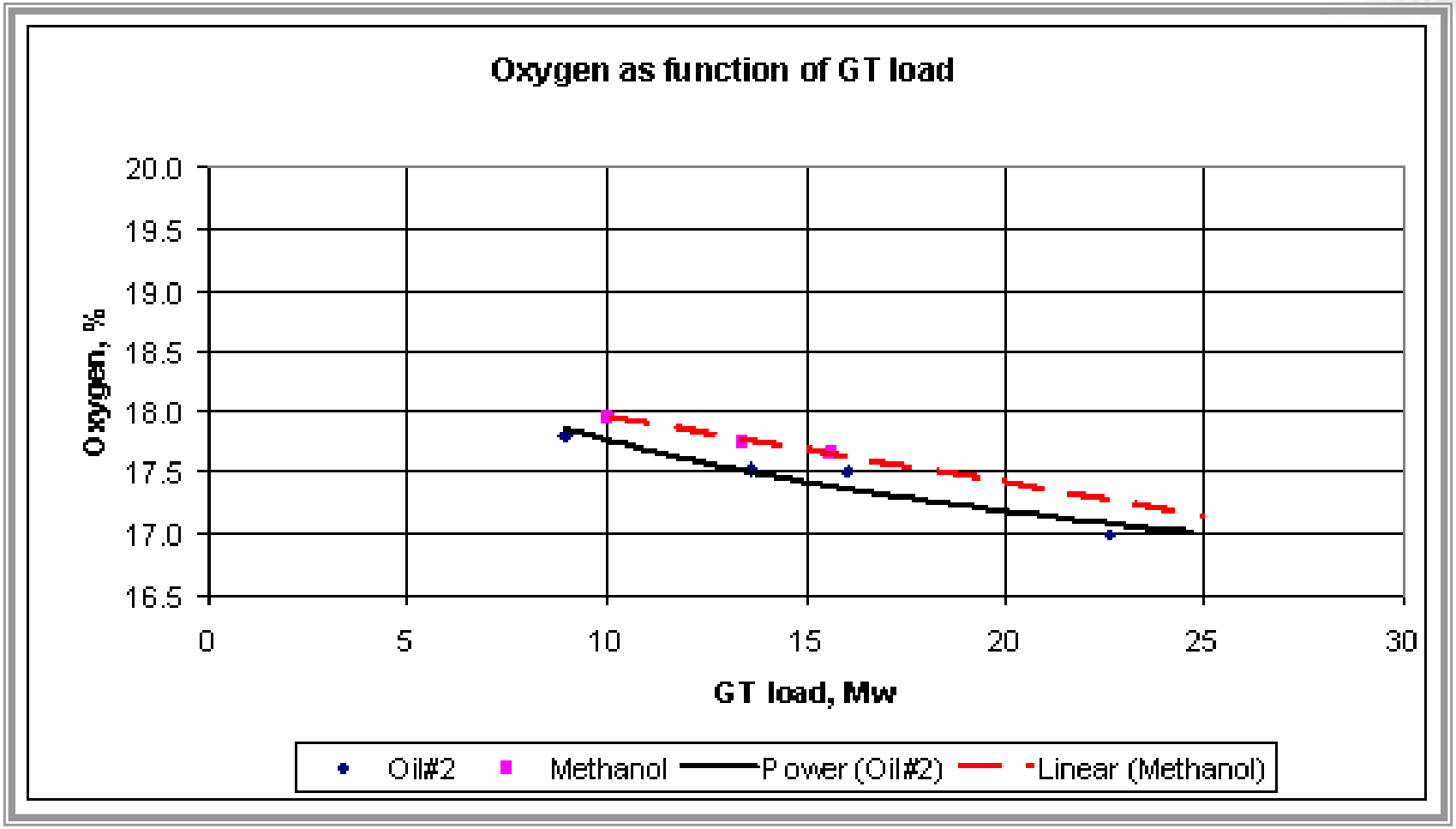
Test Results

CO



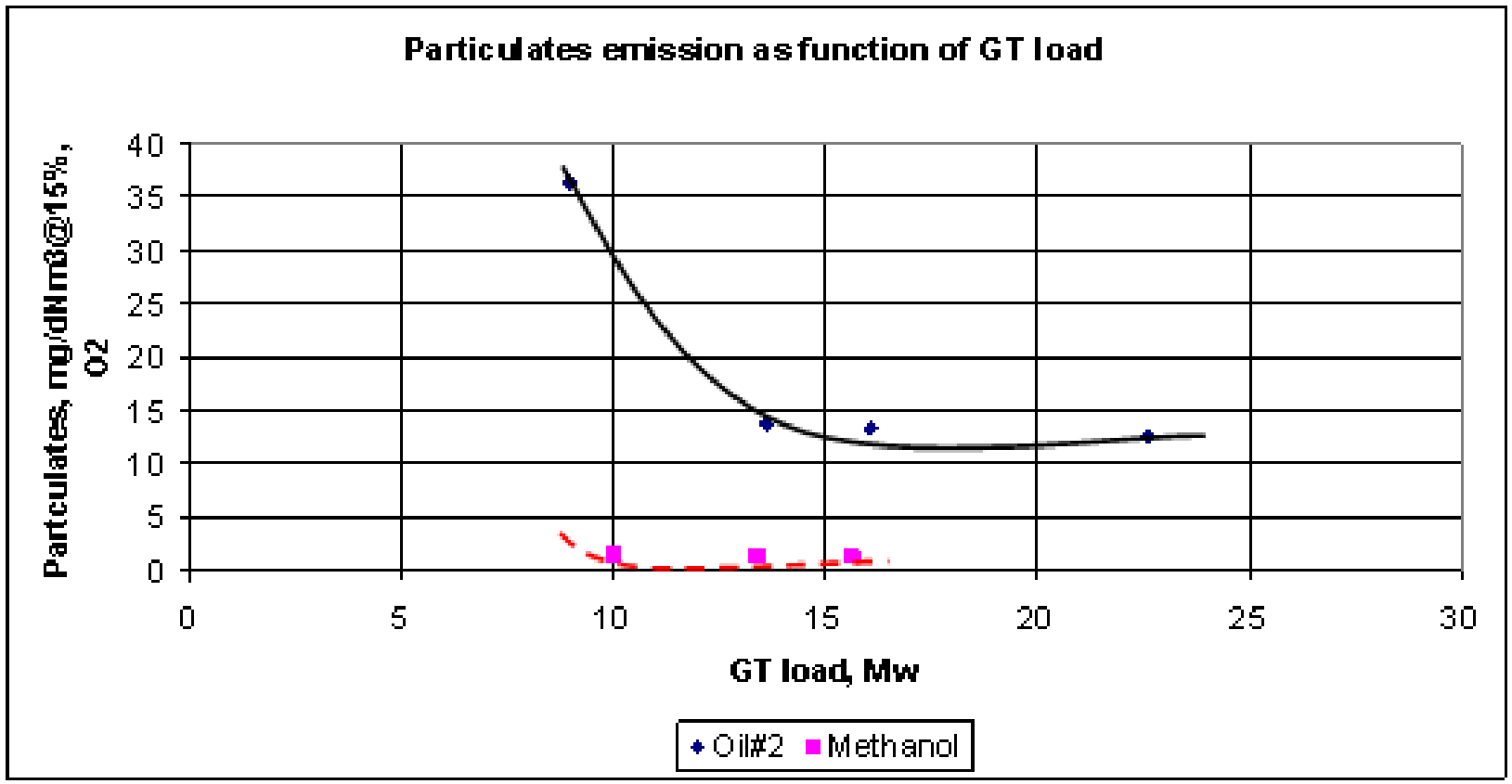
Test results

Oxygen



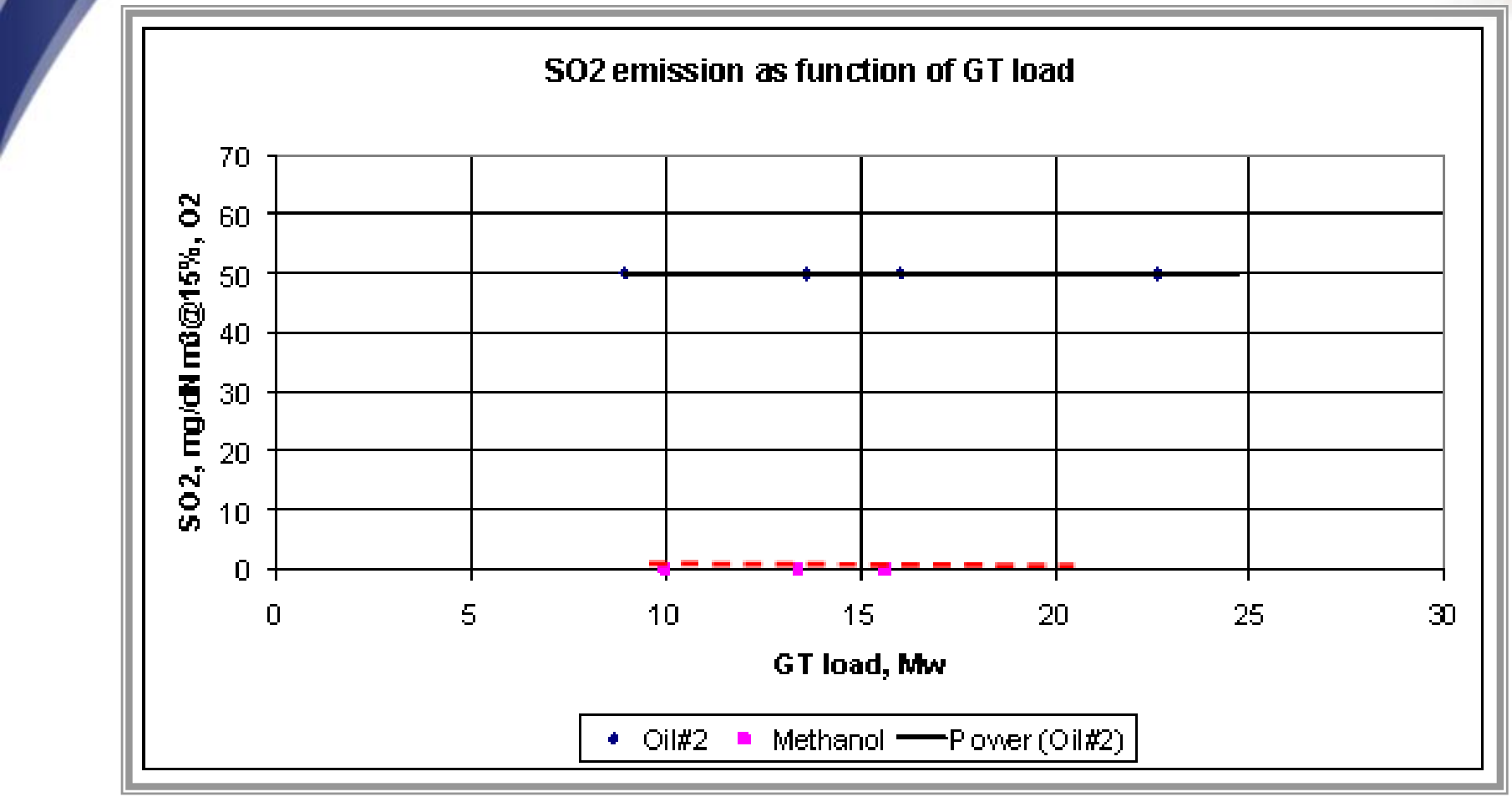
Test Results

Particulates



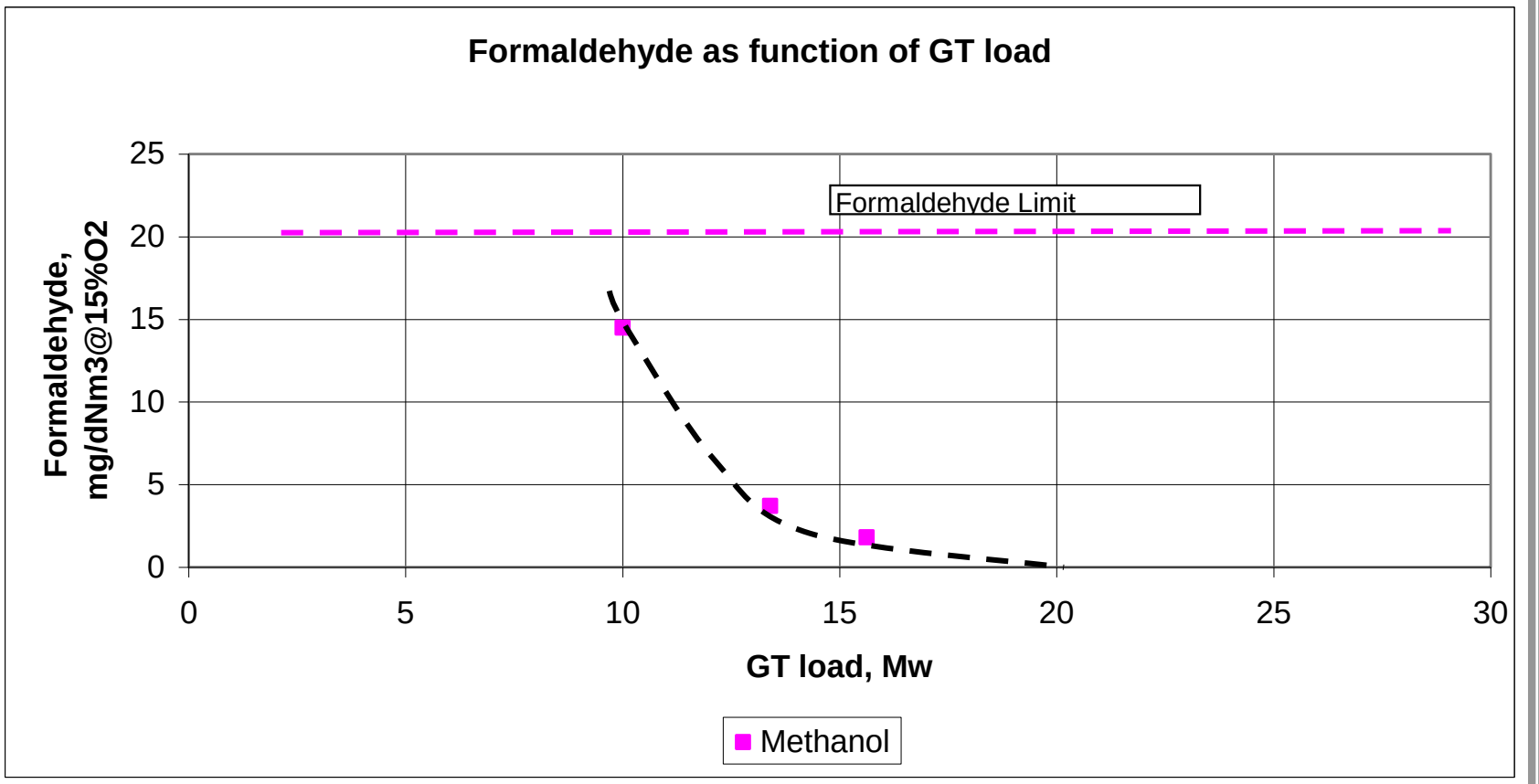
Test Results

SO2



Test Results

Formaldehyde



Following Stage Modification for a Long-Term Methanol Firing Test in Eilat

The Plan

A project to convert FT4C TWIN PAC 50 MW GT Unit in Eilat to Methanol firing (identical to the unit in Caesarea).

Objectives

To restore the full capacity of the machine and to gain long-term operating experience of working with methanol-fueled GT.

Schedule

Following summers for two years.

How To Restore Capacity?

The flow must be doubled.

There are a few bottle necks, as follows:

- HP pumps (Gear Box Driven) – external pumps assembled on a skid
- Modulating Valve – omitted – flows are controlled by a Variable Speed Drive (VSD)
- Pressure & Dump (P&D) valves – replacement of strainer
- Firing nozzles – **Excello Nozzles** are replaced by set of **High Flow Delevan Nozzles** (which were developed for water injection to enable doubling the flow).

Two-Phase Test (in Eilat)

- **Short-term:**

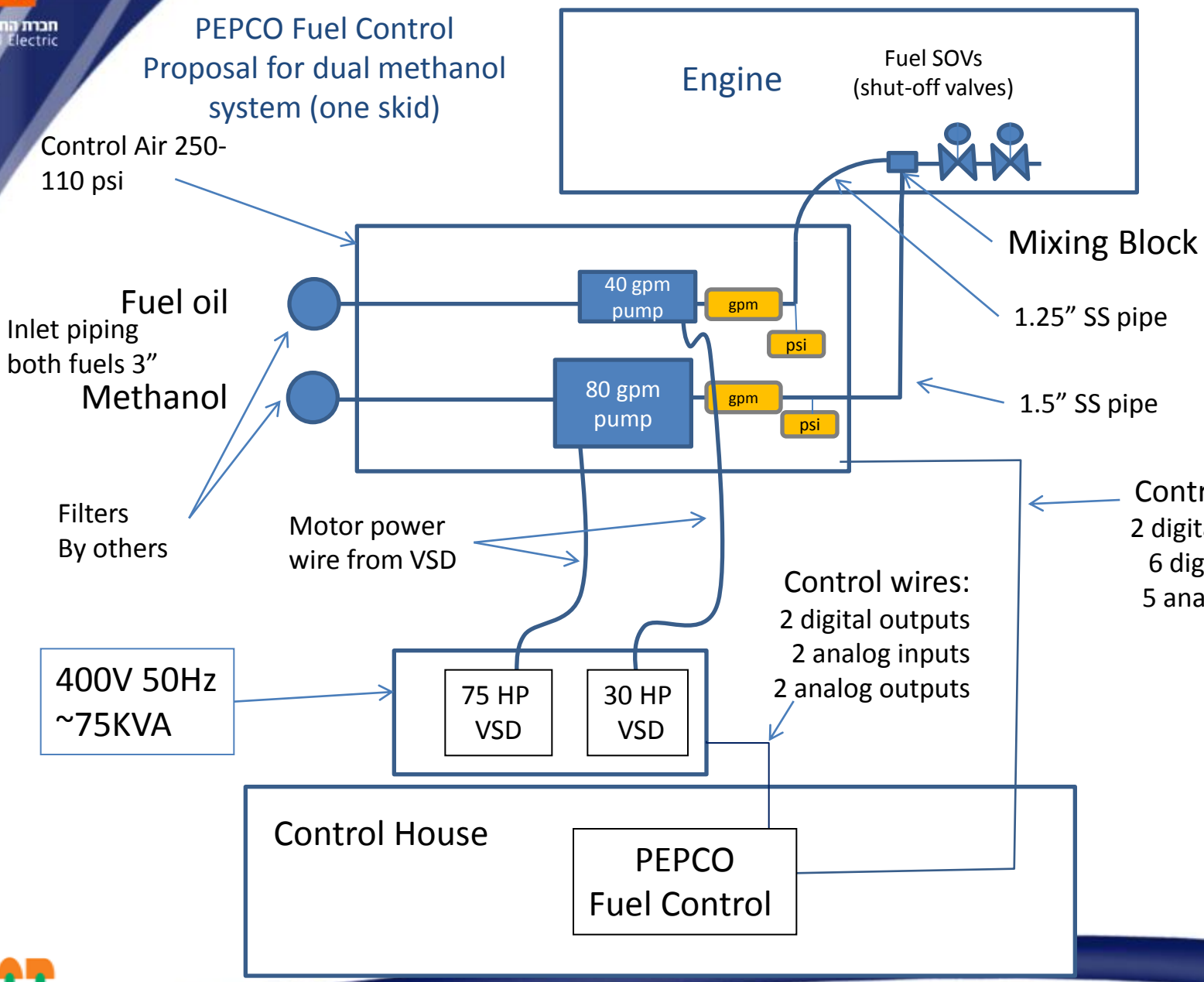
Check feasibility of the system and validate performance and low emissions (2-3 weeks).

- **Long-term:**

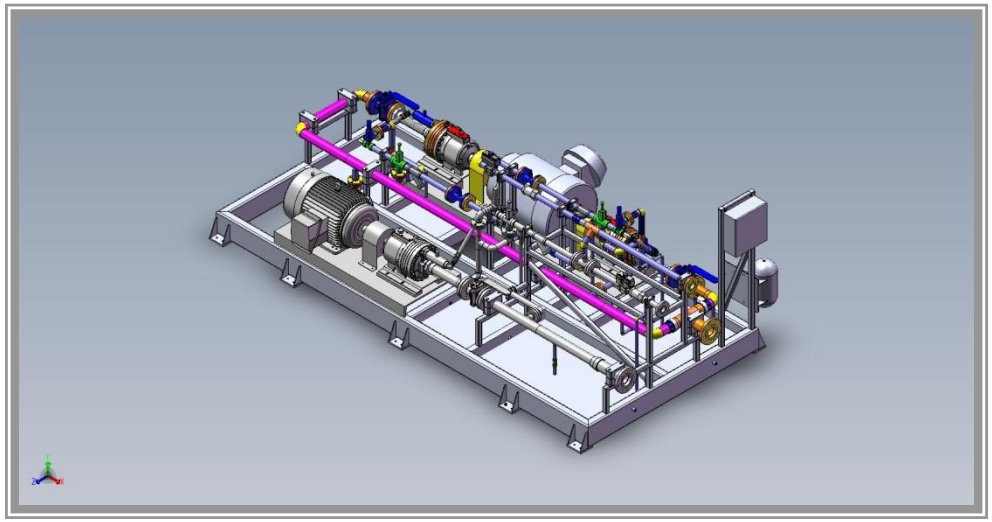
Gain operational experience and confidence in the system (2-3 years, 1500-2000 hours each year).

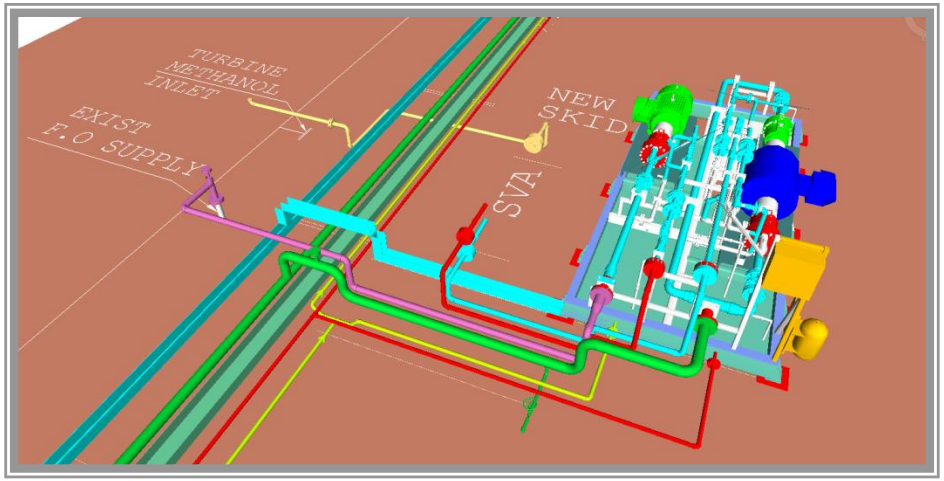
Restoring Capacity – Fuel Control & External Pumps

PEPCO Fuel Control
Proposal for dual methanol system (one skid)



External High-Pressure Pumps





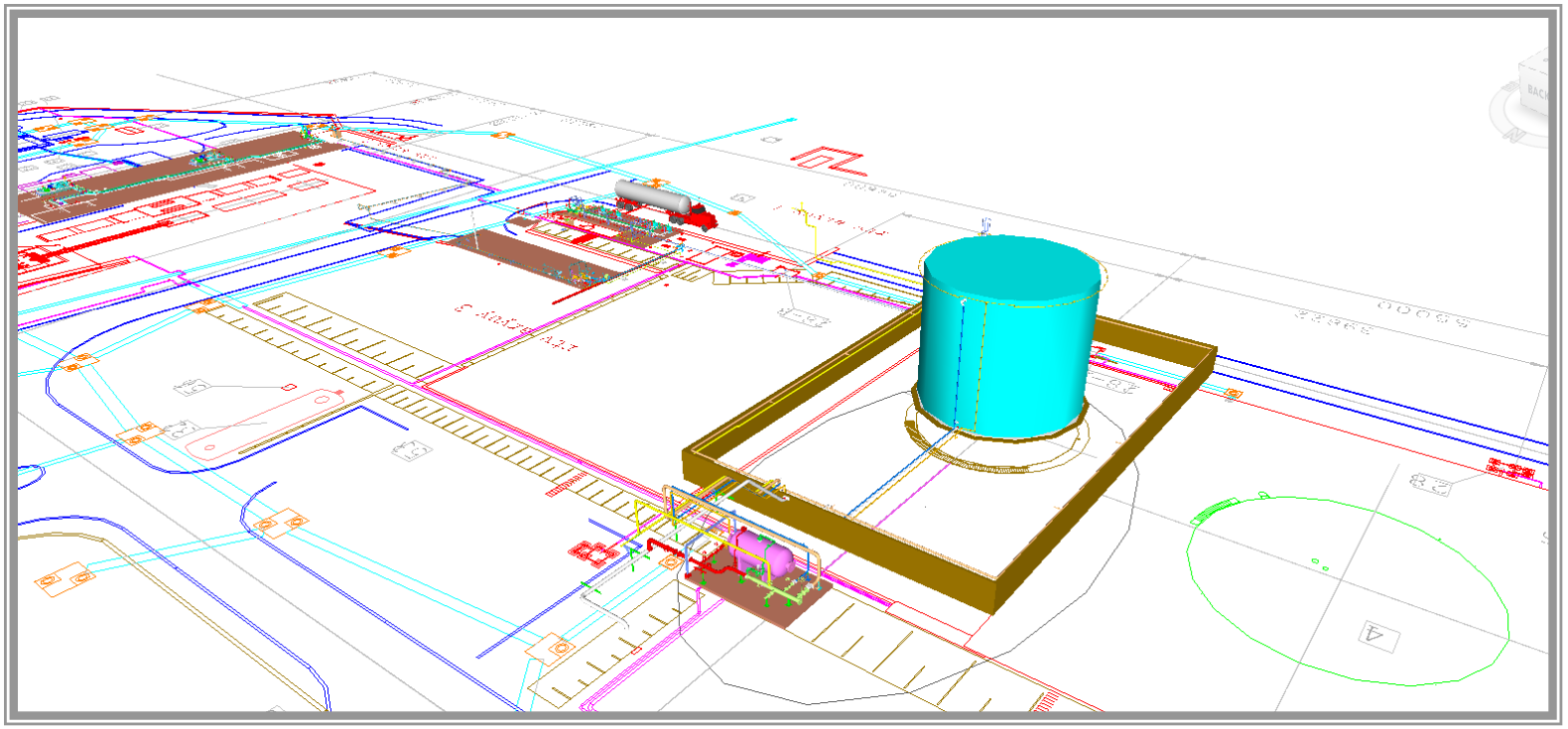
Replacing Nozzles to Delevan High Flow

Delevan Nozzles

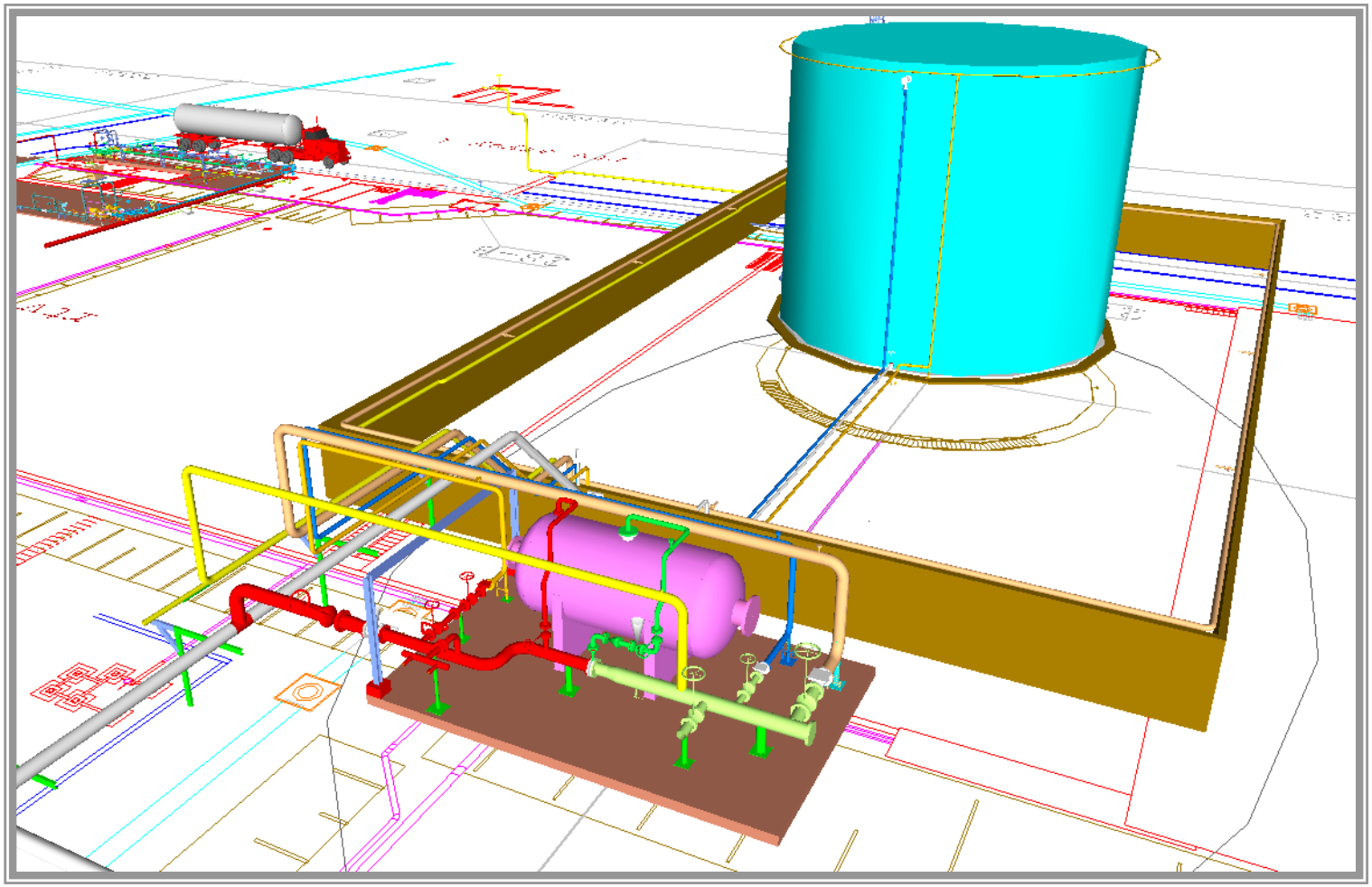
Excello Nozzles

Adapting Fuel Unloading and Storage System

- New unloading piping
- Tank adaptation – floating roof



Adapting Fire-Fighting System



Fuel Unloading Platform

Summary

The results presented here clearly show that with minor low cost fuel system retrofit, methanol firing leads to significant NOx, SO2, and particulates emission reduction, without affecting performance.

We believe that the results of the present work can be applied to other boilers and gas turbines.