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HAZARDS ASSOCIATED WITH NEW COKING, HYDRO-TREATMENT AND HYDROGEN UNITS

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HISTORICAL

- Hazard Identification => Overall View on COKING + HYDROTREATMENT of AUXILIARY Units.
- Initial Purpose => Prevention and design of fire fighting systems.
- Hazard Identification => Operational
  Fire Accidents
- Coke Units => Batch operation => "Unusual" Type of Operation
  Physically Demanding
  Proximity *Operators x Hazards*
- Associated Units => Toxic Products
  Flammable products
  Very high pressures
  Few blockage points (large inventory)

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UNITS PRESENTATION

PETROBRÁS Objective => Production of clean fuels, better quality and higher added value.

This specific case of that Refinery => the following units:

- (1) Delayed Coke Unit;
- (1) Unstable Hydro Treatment Unit;
- (1) Naphtha Hydro Treatment Unit;
- (1) Hydrogen Generation Unit, to be used in the HDT Units.
- Some other auxiliary units, like Sour Water Treatment Units, Sulfur Recovery and Tail Gas Units, Power Generation and also Clean and Waste Water Treatments revamping.

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WORK METHODOLOGY

1ST => Identification and selection of notable risk scenarios, representative of the severity associated to the new units;

2ND => Fire simulation Flames => (size, characteristics), Duration => (blocked volume);

3RD => Thermal model (Dimensional characteristics of equipments and structures);

4TH => Calculation of thermal problem with distribution of temperatures values in the structure, along the time, in a nonlinear and transient procedure;

5TH => Evaluating the fire action, fire risk propagation and the necessary protection measures, comparing with standards and specifications.

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SOFTWARES

- ANSYS - software developed by ANSYS Inc., specific for thermal and structural analysis using the Finite Elements Method, allowing consideration of non-linearity of material and geometry, besides algorithms solution in an optimized and stable way.

- ARGOS - Developed by MTL team, simulating fire accidents caused by gas or oil in different conditions, considering or not the action of depressurization systems, several orifice diameters and presence of structural elements.

- CFX - software distributed by ANSYS Inc., specific for fluid-dynamic analysis problems.

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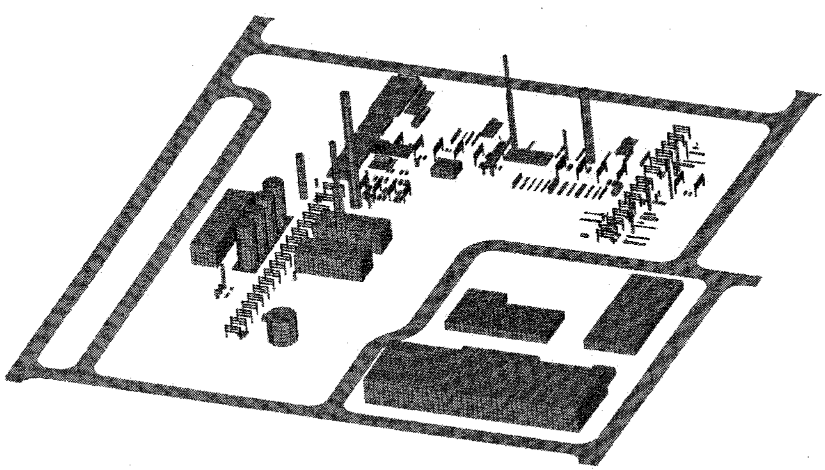
Figure 1.0 - Equipment details and structural elements of Delayed Coking Unit.



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Gas Dispersion Analysis

Unstable Hydro Treating Unit (UHT)

- ✓ Modeled through fluid-dynamic three-dimensional finite volumes, allowing the calculation of the velocity field and gas concentrations, starting from a non-disturbed area.
- ✓ Winds directions and intensities comply with the winds defined (velocity field and pressure from the solution of Navier-Stokes equation, which represents the discharge, for each nodal point of the model).
- ✓ Determination of air velocity field for different wind conditions, gas release is applied in the equipment to analyze over the air discharge.
- ✓ Determination of discharge resulting gas concentrations and compared to gas Lower Explosive Level (LEL).

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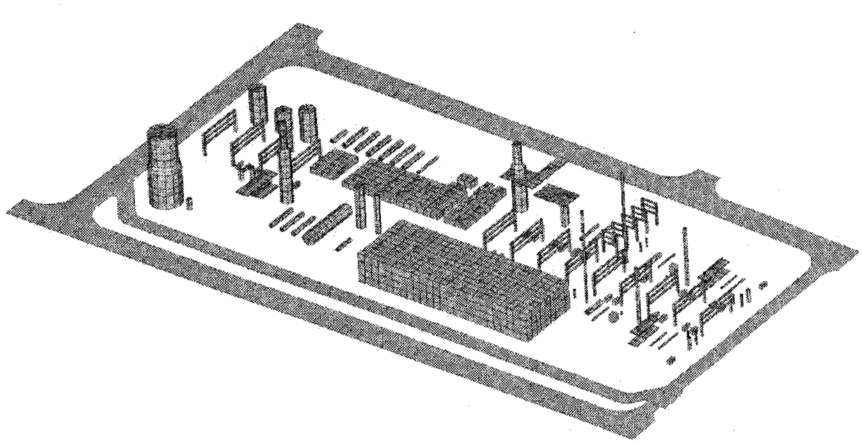
Figure 2.0 - Equipment details and structural elements of Unstable Hydro Treating Unit (UHT).



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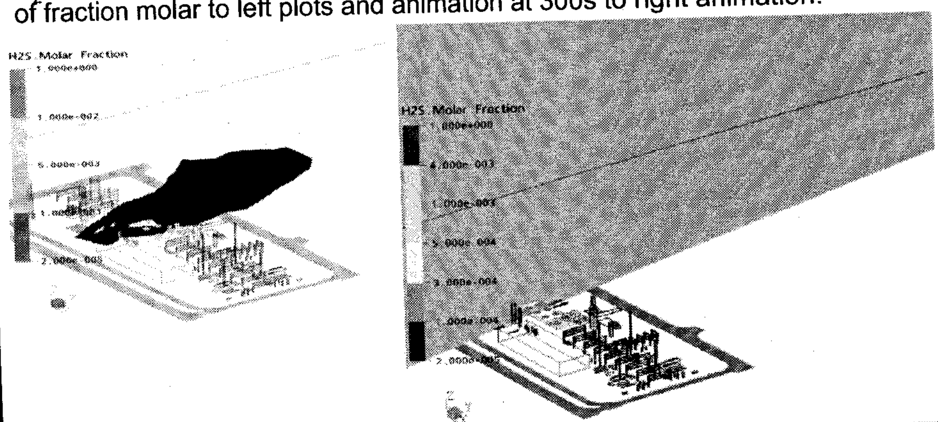
Gas Dispersion on Vessel V-02 with Orifice of 1"

Figure 3.0 - Three-dimensional perspective of a gas cloud, possibly rich in H_2S, for the time of 60s and concentrations starting from 20ppm (blue color) of fraction molar to left plots and animation at 300s to right animation.



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✓This scenario (Figure 3.0) is characterized by the gas release and formation of cloud from vessel V-02 of UHT Unit. Orifice of 1" diameter in the base is considered for gas leak with predominant wind of 2 m/s.

✓Fire simulations + dispersion of toxic gases in the units of Refinery Modernization Project besides the risks associated to the steam formation/release though the upper cover (presence of hot spots).

✓Results were presented considering different leak orifices and the action of safety systems, including depressurization and intermediate blockages.

✓Next Figure 4.0 presents the result for Delayed Coking Unit, pool fire in the Coke Drum of one of its Coking Reactors, wind speed of 2 m/s and temperatures distribution after 900 s of fire beginning.

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Figure 4.0 - Global vision of temperature distribution, with values above 800°C in Pipe Rack, 228°C in Reactor C, 210°C in Reactor D and 74°C in Furnace.

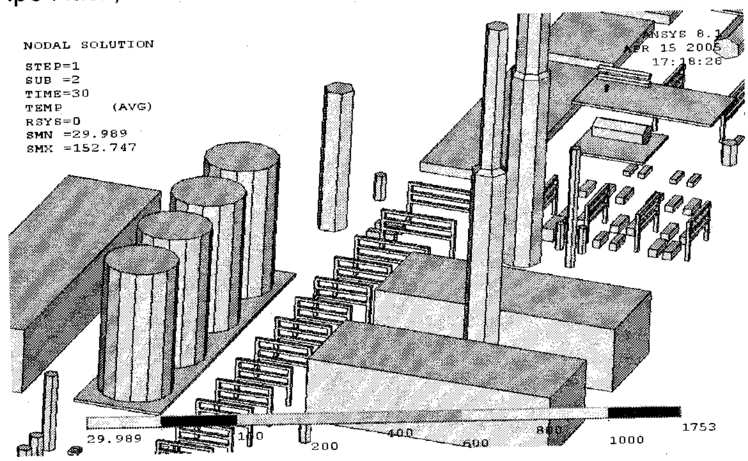

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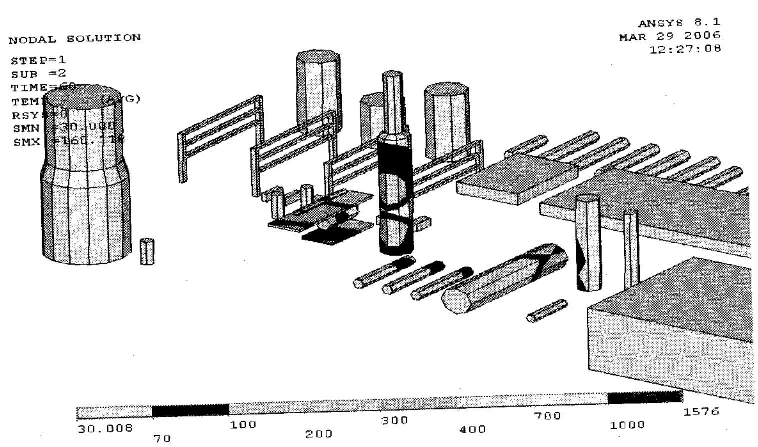
Figure 5.0 - Jet Fire simulation result in V-02 (t = 3600s) with 416m^3 of Gas - orifice of 1½" without depressurization.



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✓This accidental scenario (Figure 5.0) is characterized by the gas release formation of jet fire, at the flange in the base of V-02 of UHT Unit.

✓Orifice of 11/2" is considered for for the gas release without depressurization, with a total volume of 416 m^3 (volume of equipment, lines and other inventories until next blockage) and the jet modeled horizontally to West unit.

✓The result is presented with temperatures distribution for the same scenario, after 3600s (60 minutes), maximum temperatures are:
1536°C in the V-03
338°C at tower T-02
869°C at heat exchanger P-08A.

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CONCLUSIONS

Fire Analysis:

i) The fire scenarios simulated in the units have indicated that high operating pressures, associated to large inventories, result in fires of considerable duration, superior to 60 minutes, and temperatures able to result in serious damages to the equipment and structures;

ii) Among the 4 Units that compose the Modernization Project of the Refinery, we selected as object of this presentation the simulation of jet fire at UHT Unit and at Hydrogen Generation Unit and pool fire at the Delayed Coker Unit;

iii) Most effective reduction form of severity associated to fire is the adoption of a depressurization system;

iv) Adoption of intermediate blockages that limit the available inventory to feed the leak is, in a lower degree, also effective. When associated to depressurization, this solution reduces the duration of the fire accident. It is more efficient in fires associated with large releases, through great dimensions orifices;

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vi) Heating process of the nearby equipment is intense, what means that is short the available time to begin the cooling of equipment in the neighboring of the fire.

vii) Analysis of the processed gases revealed streams with possible high levels of toxic gases. The leaks dispersion analysis associated with these streams showed considerable ranges of toxic clouds, but contained to the limits of the refinery;

Specific Operational risks of the Coke Unit:

viii) Regarding the risks that are not directly associated with fires, it was verified that the number of fatalities associated to burns is elevated;

ix) All references associate these accidents to (a) human presence close to Coke Drums, (b) non-continuous operation regime, in batch, that demand attention and constant interventions, many times with significant physical effort;

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RECOMMENDATIONS:

i) Implementation of devices for gas units depressurization in high pressures;

ii) Evaluate, case by case, the inclusion of intermediate blockages, for liquid inventories with volumes higher than 50 m3;

iii) Implementation of automatic fire detection in all units;

iv) Implementation of gas leak detection, concerning to hydrocarbons and other gases in all units;

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v) Automation of the cooling in the neighboring surfaces of Coke Drums and/or other vessels, with automatic monitors or deluge system;

vi) Evaluate the use of deluge system to reach the whole vessel surface;

vii) Automation of the Coke Drum upper valve, reducing the risk of burns due to hot water jet or steam;

viii) Automation of the Coke Drum lower valve, reducing the risk of personal accidents;

ix) Installation of a cabin for operator in platforms area of Coke Drum;

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x) Installation of a deluge system or heat-shield to the lateral catwalks of Coke Drums

xi) Installation of interlocks for the line-up of batch operation. The selection of these interlocks based on the records of operational incidents during valve actuation or through specific risk analysis;

xii) Installation of an alarm panel for the most critical valves and shall be evaluated the use of manual valve for system redundancy;

xiii) Installation of an interlocked automated system and pre-determined sequential valves operation, so that certain conditions are reached to allow opening or closing the valves, if confirmed that this drum is capable to receive this load;

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xiv) Determination of the expected composition of the released vapors, observing for H2S, CO and SOx, during the drums opening. Operators should use compatible equipments with the type of expected gases.

xv) Elaboration of a specific procedure for handling and discarding radioactive capsules used in Coke Drums level sensors, contemplating eventual accidental situations, such as fires, mechanical shocks and capsules falls.

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