Oct 13, 2017

UOP Phenol 3G Technology

Low Cost Phenol Production with Improved Safety

Honeywell UOP

Agenda: UOP Phenol 3G

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- Process Overview
- Safety In Design
- Process Description and Improvements
  - Chemical Reactions
  - Oxidation Section
  - Decomposition
  - Dehydrator
  - Direct Neutralization
  - Phenol Fractionation
- Summary

UOP Phenol 3G Technology

- Offers growth prospects and opportunity to vertical integrate petrochemical assets via phenol to bis-phenol A to polycarbonate production
- A lower OPEX, CAPEX and smaller footprint commercialized option
- Potential economic advantages:
  - Reduction of up to $38 per ton of phenol in net cost of production (NCOP)
  - >$49MM increase in net present value (NPV) relative to competing technology
  - >17% steam reduction using novel phenol recovery fractionation technology
  - >13% reduction in capital expenses.
  - Up to 50% waste water reduction due to improved design
  - Higher phenol yield
  - Further improvements in feedstock efficiency possible with combined UOP Phenol 3G and UOP Q-Max cumene alkylation technology

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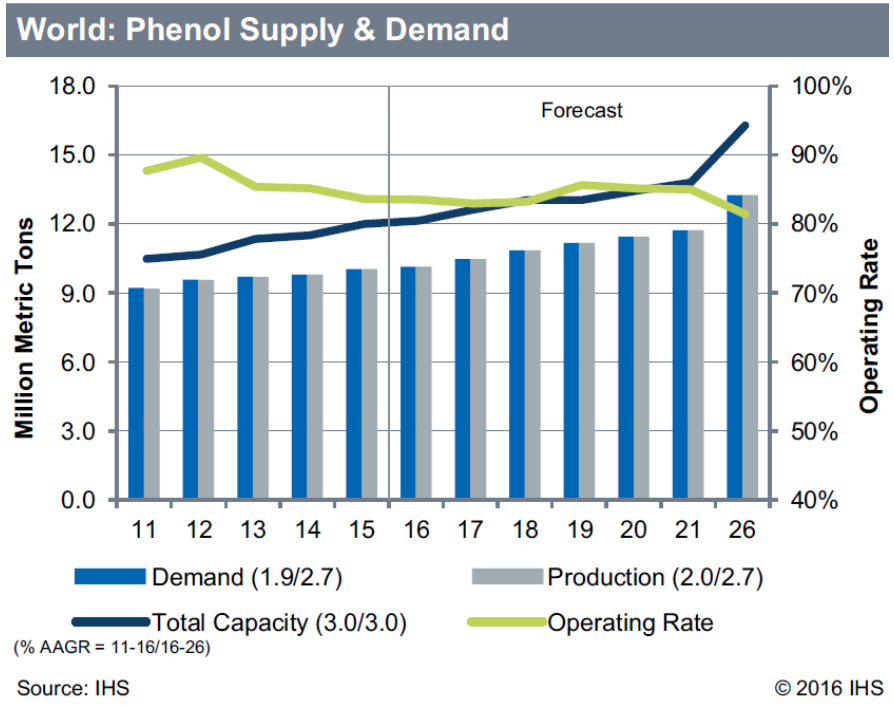
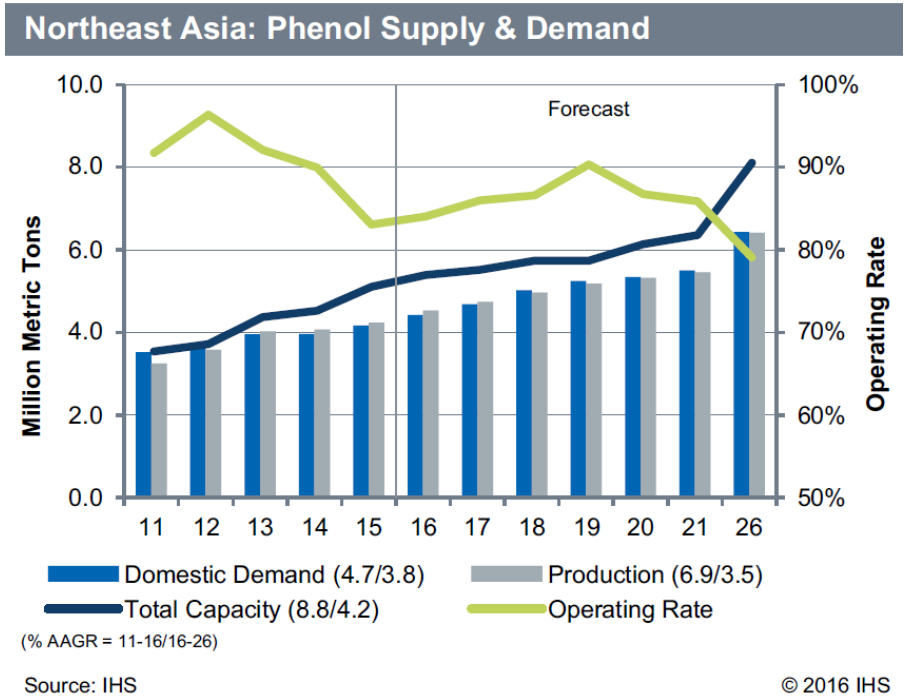
Phenol Market Segment Overview



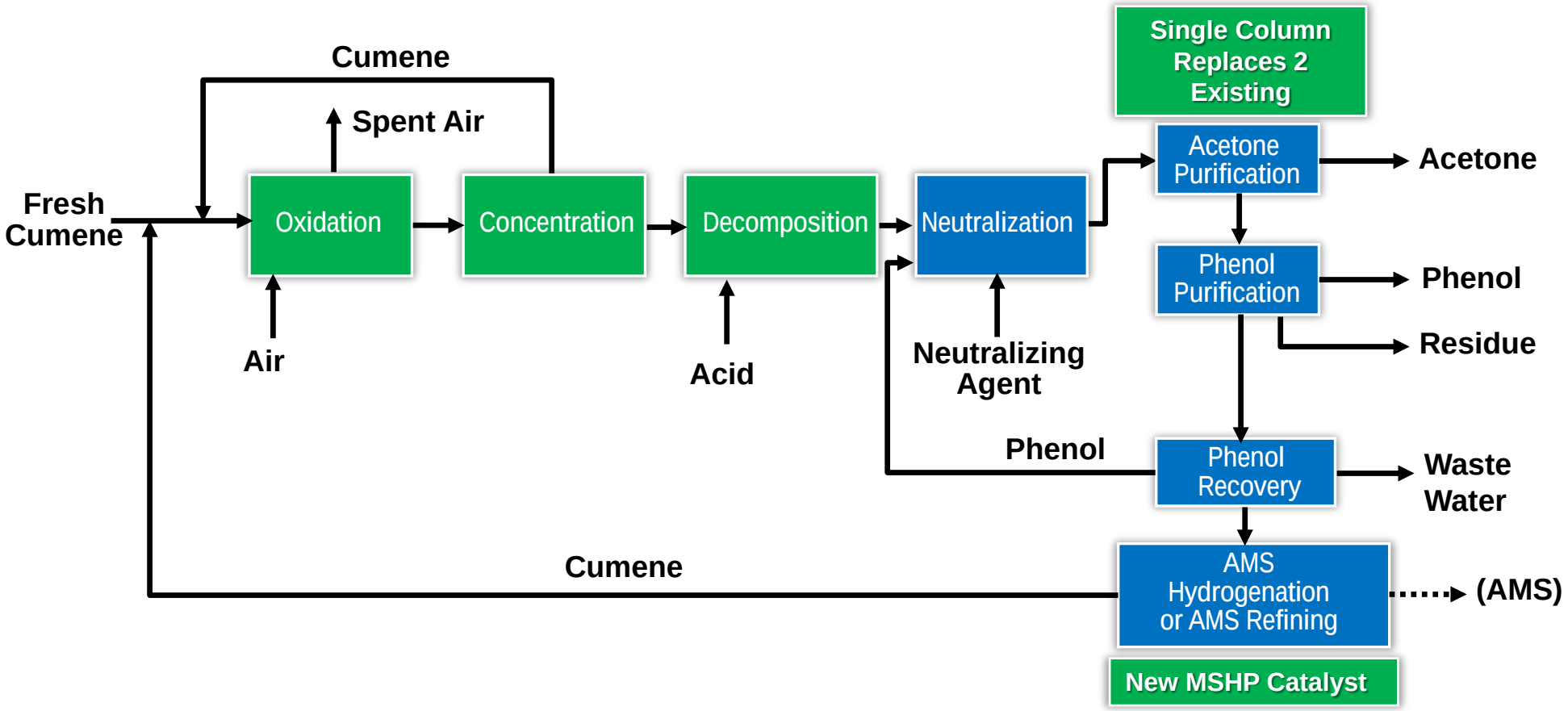
- World demand projected to grow at 2.7% CAGR though 2026 (~300-350 kMTA per year)
- 2 new Q-max and 1 new Phenol units licensed over the past 3 years; market tightening expected by 2020.

- Majority of capacity investment will take place in China, India and Asia Pacific
- New capacity to be integrated Cumene-Phenol units
- Asia has a very high degree of integration (90%+)



Source: © IHS Global Inc

UOP Phenol 3G Process



Key Areas of Improvements

Phenol 3G vs. Competition - Net

	Competing Technology	UOP Phenol 3G
NPV, $MM	BASE	BASE + 49
Cost of Production (NCOP), $ per ton of Phenol	BASE	BASE – 38
Feed Consumption, % tons of cumene/ ton of phenol	BASE	BASE - 0.5%
Utilities Cost, %	BASE	BASE – 17%

Basis: 300 kMTA phenol unit

UOP Phenol 3G Safety Features - Oxidation

- Pressure Relief Devices are designed for relief containment
- Utilizes active safety systems for temperature control
- Reduced CHP inventory
- Dedicated emergency coolers plus water injection system for mitigating CHP thermal decomposition runaway event
- Cumene transfer / deluge to reduce exotherm rate
- Redundant electrical grids in addition to steam drivers and/or standby diesel for emergency pumps

Design validated with Quantitative Risk Assessment (QRA)

Safety In Phenol 3G Design

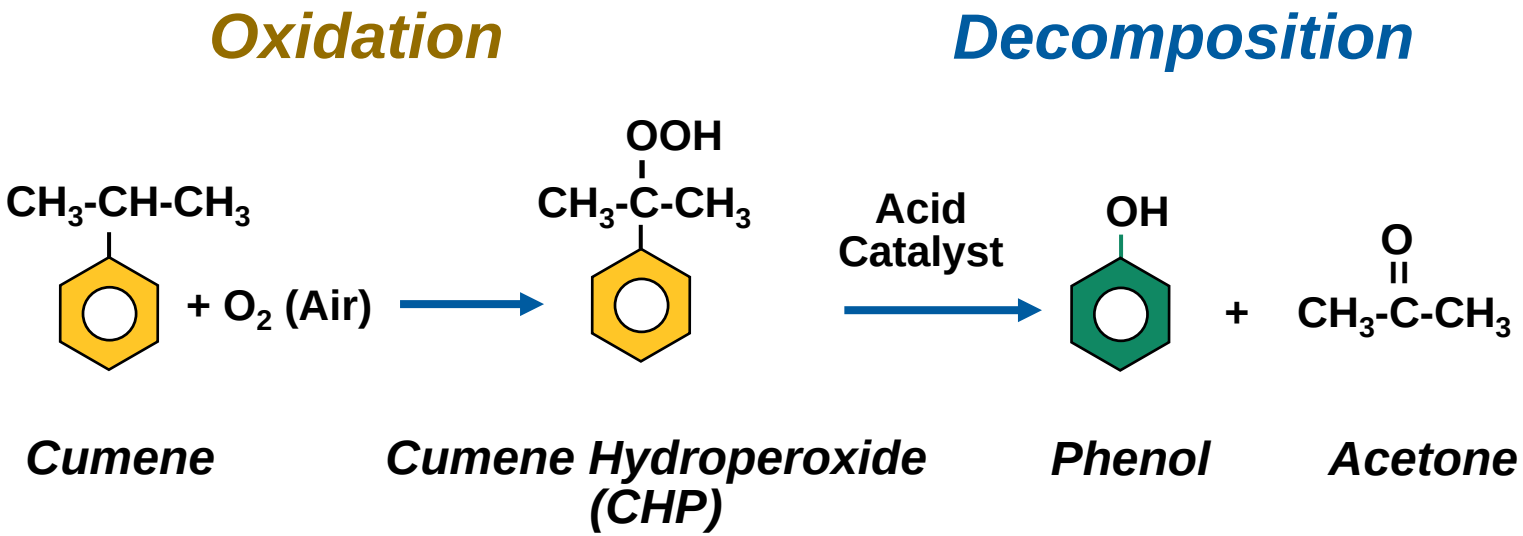
Concentration Section

- Design for ease of operation / reduced capital cost
- Virtually no inventory of hot CHP
- Integral cooling of CHP concentrate.
- 3G design does not have re-boiling of concentrated CHP.

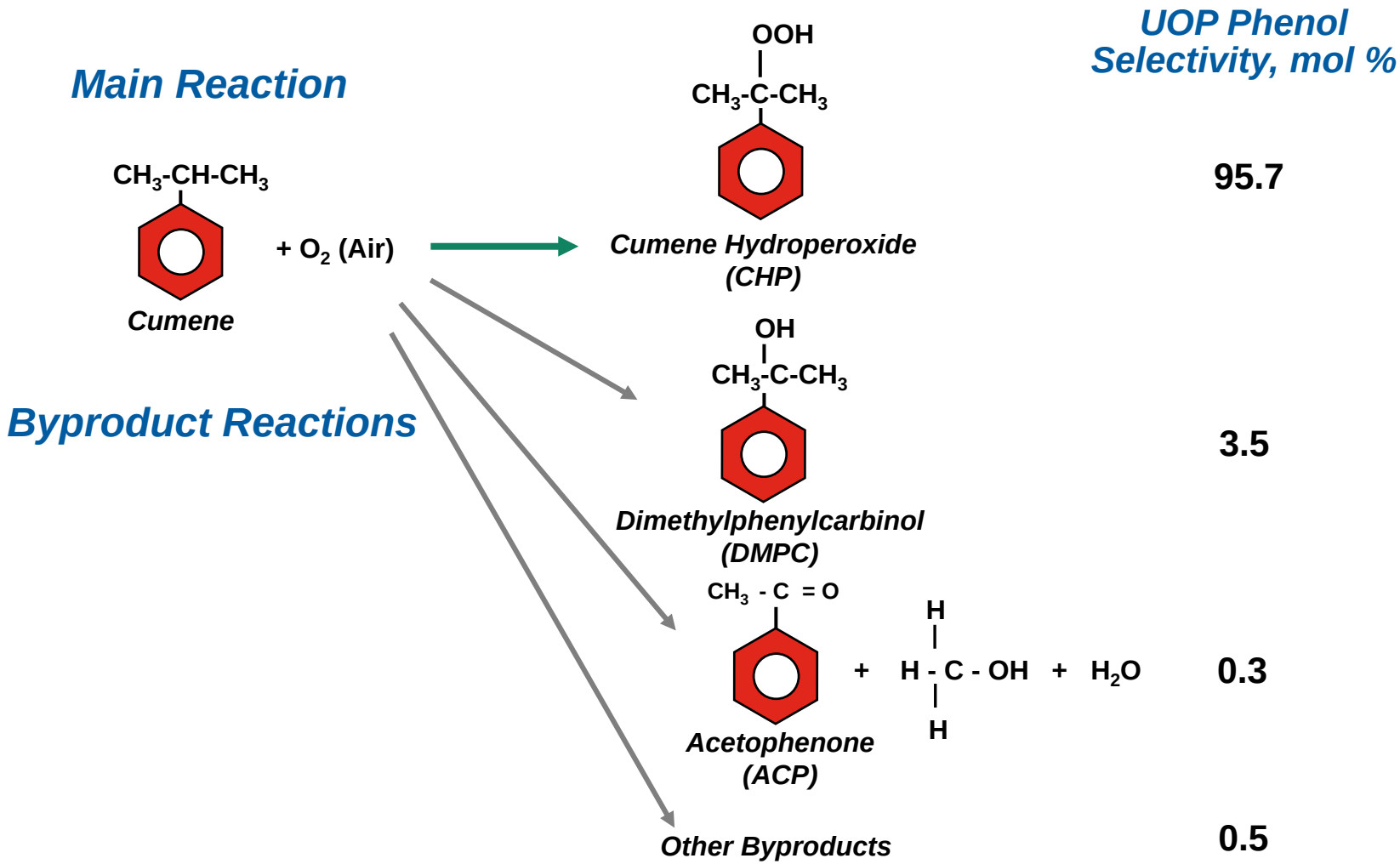
Decomposer Section

- Non-boiling decomposer is more stable / easier to control
- Multiple independent acid injection points for better reliability
- High yields with no acetone recycle
- Less byproduct (acetol)/ lower phenol purification costs
- No distillation costs to produce acetone for recycle

Main Reactions

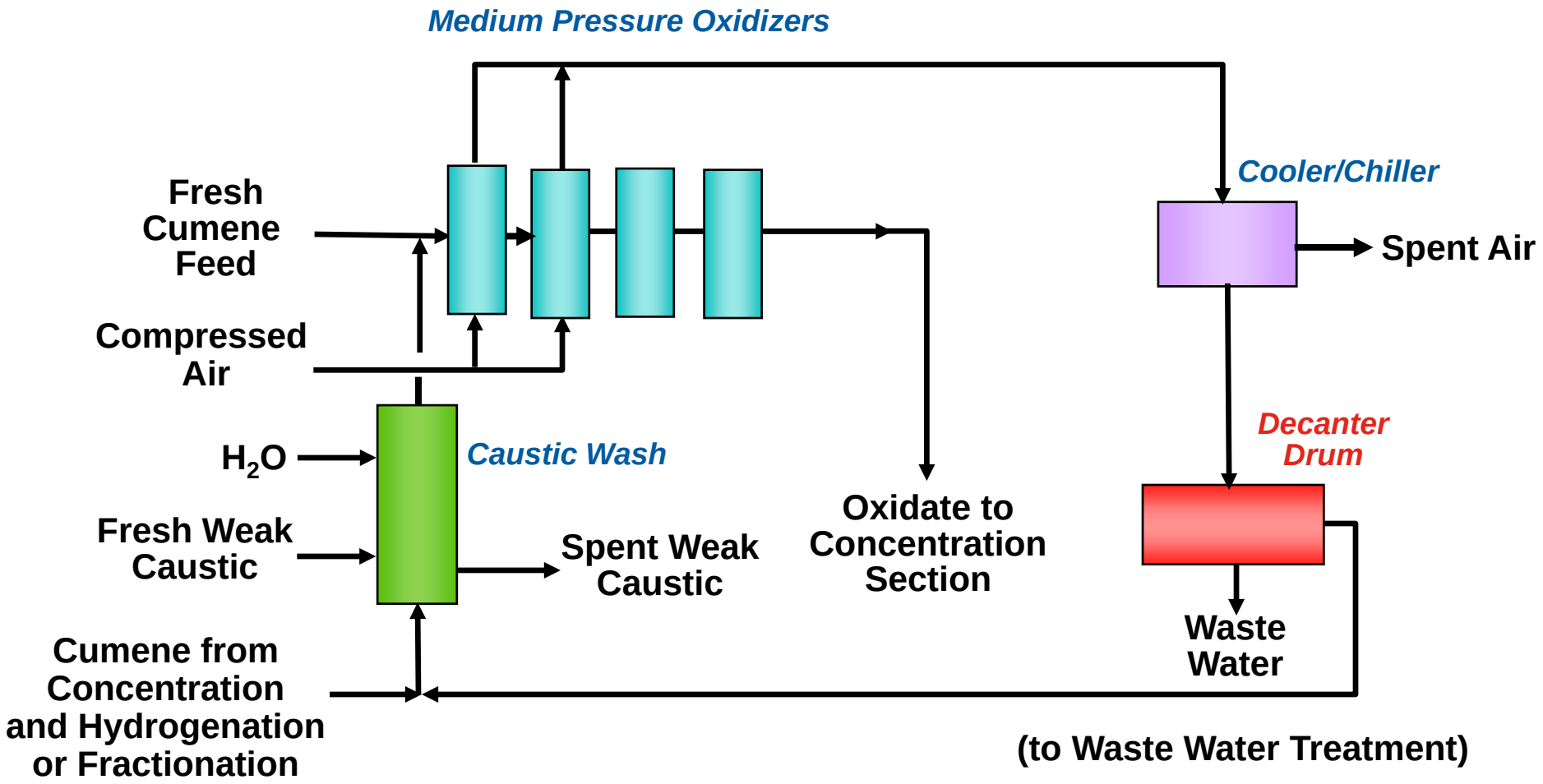


Oxidation Reactions

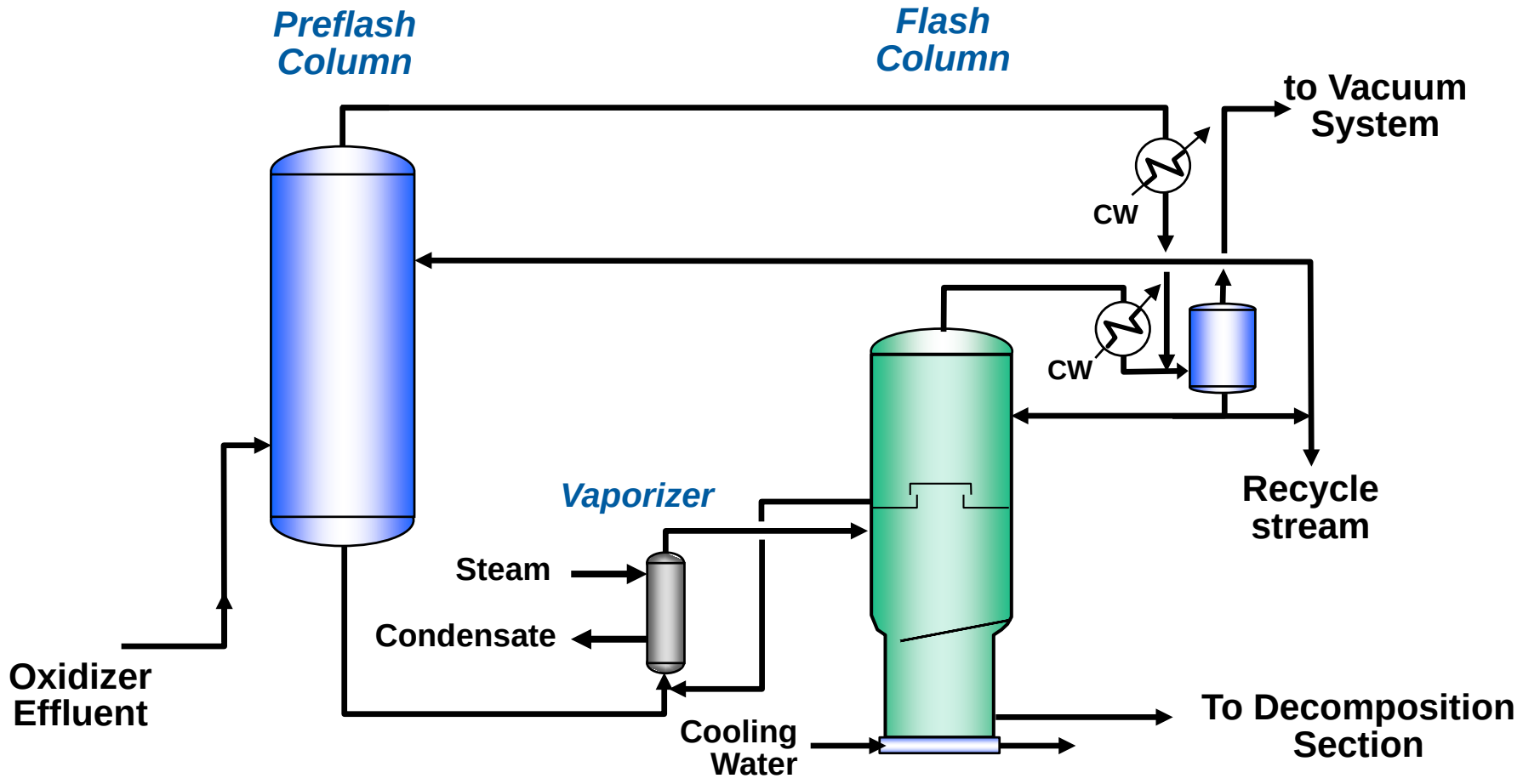


Medium-Pressure Oxidation produces high CHP yield necessary for lowest cumene/phenol without acetone recycle

Oxidation Section

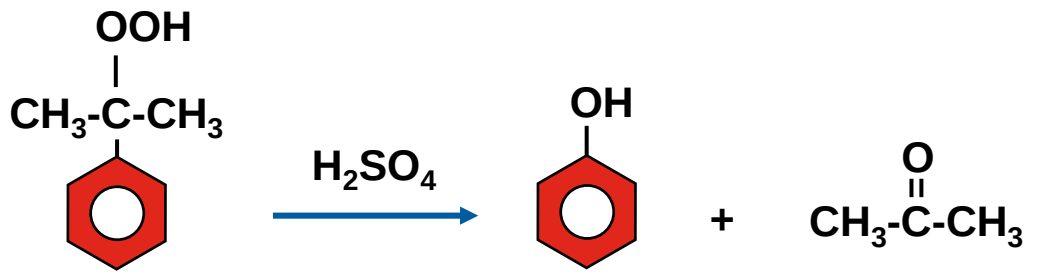


Concentration Section



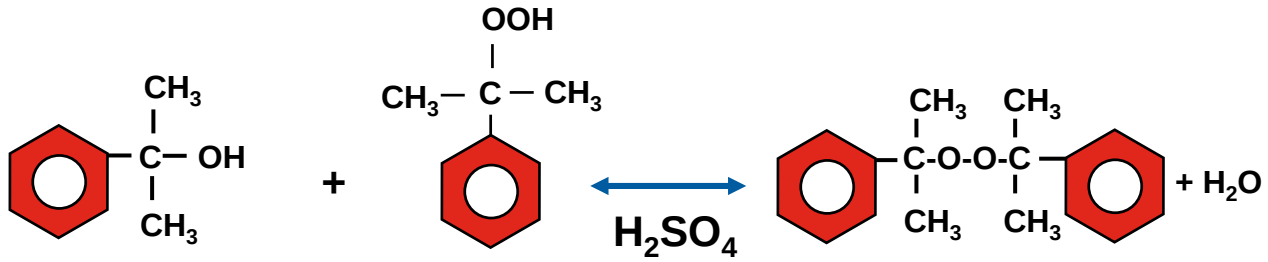
Decomposer Main Reactions

Main Reaction:



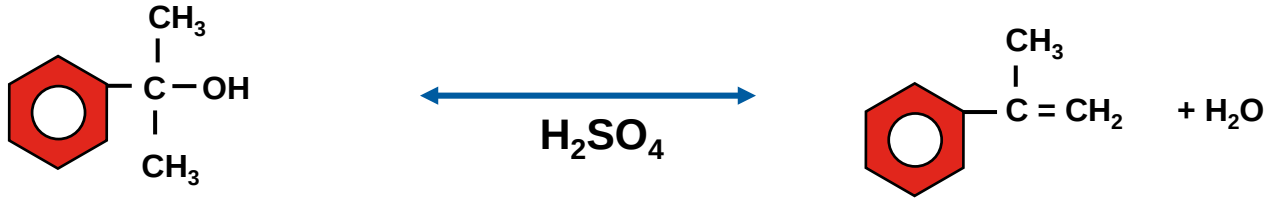
Cumene Hydroperoxide (CHP) — *Phenol* — *Acetone*

Desired:



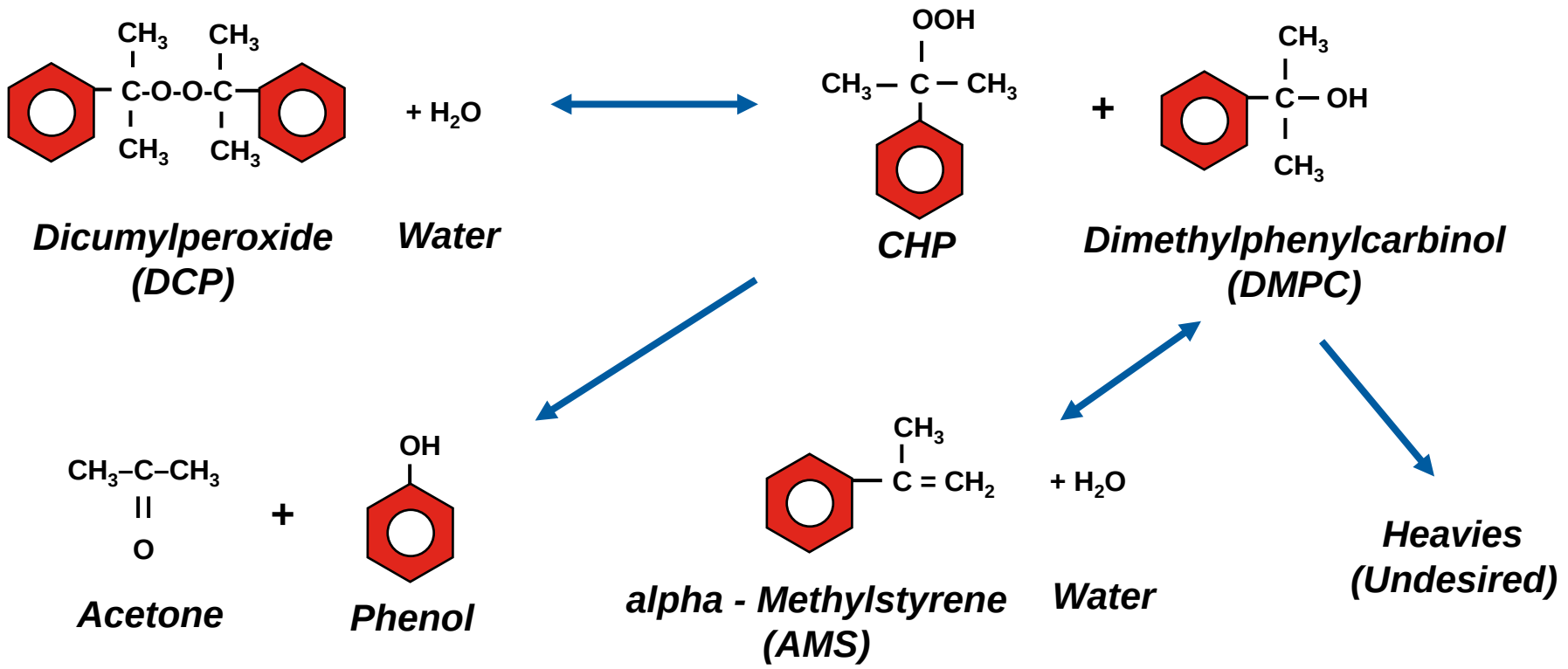
Dimethylphenylcarbinol (DMPC) — *CHP* — *Dicumylperoxide (DCP)* — *Water*

Not Desired:



Dimethylphenylcarbinol (DMPC) — *alpha – Methylstyrene (AMS)* — *Water*

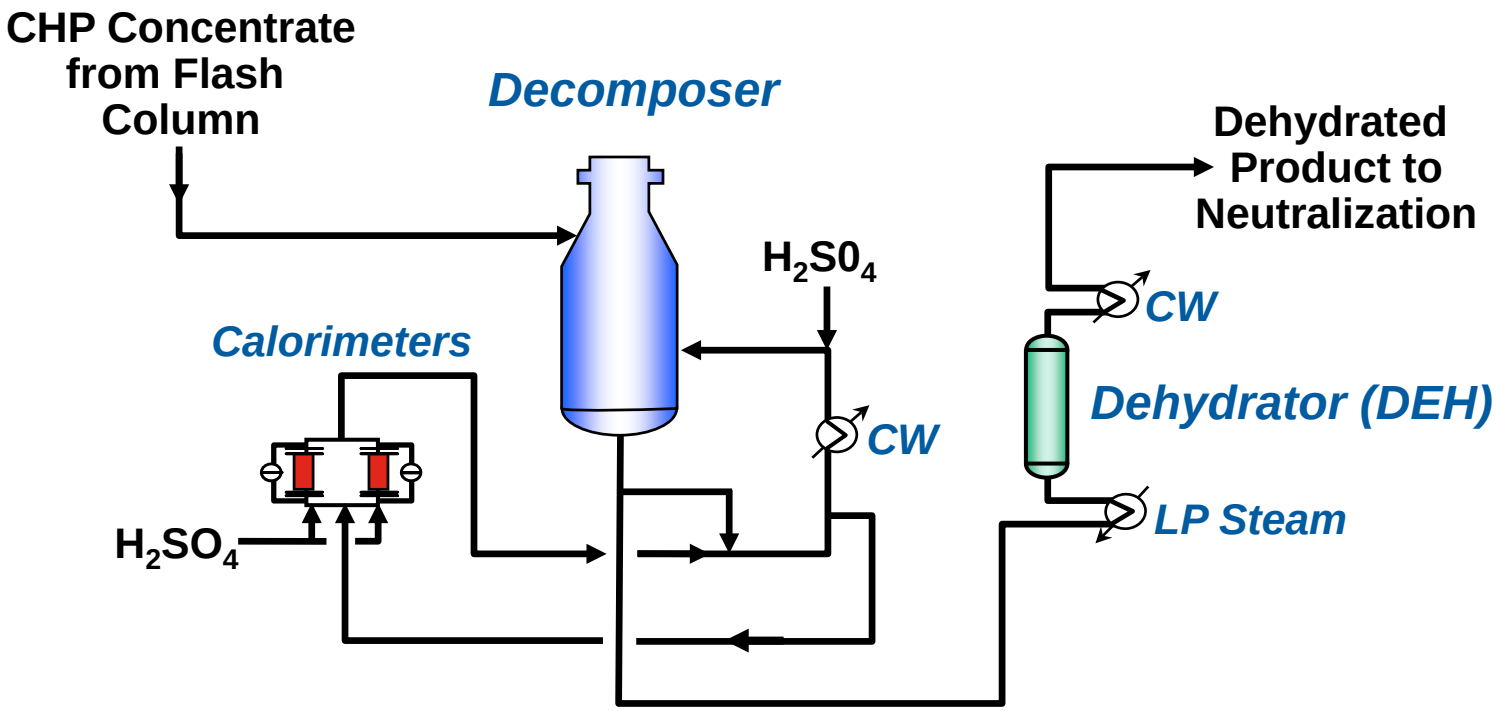
Dehydrator Main Reactions



UOP Decomposition technology helps maximize AMS yield without acetone recycle

Decomposition Section

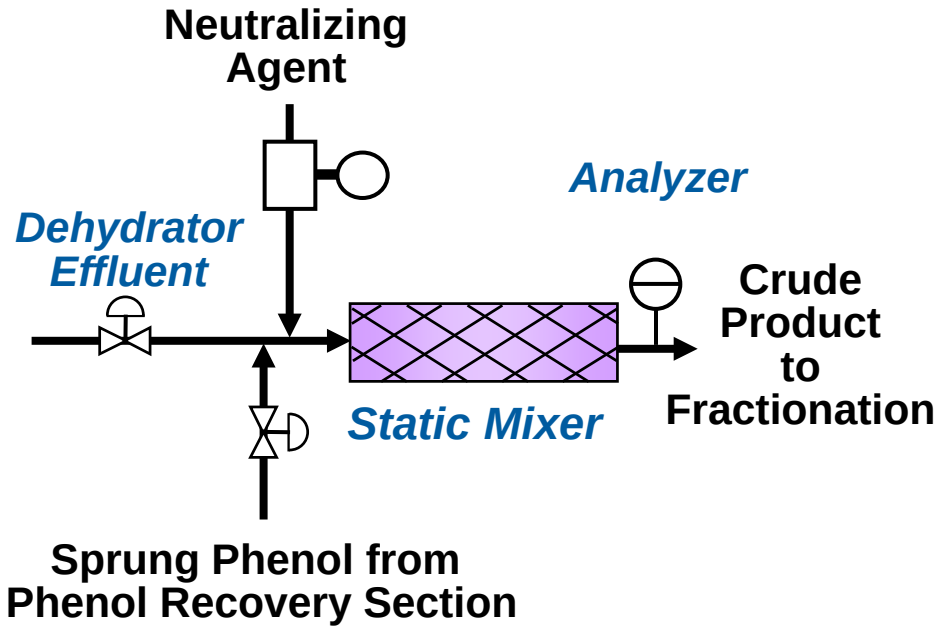
Two-Stage Decomposition



Maximum Yield Achieved via Phenol 3G Improvements

Direct Neutralization System

Proprietary Neutralization System and Agent



- Eliminates reboiler fouling in downstream product fractionation
- Results in higher uptime/operating rate
- Lower capital cost
- Easy and safe to operate
- Lower maintenance cost

No Periodic Shutdowns Required to Clean Fractionation

UOP Phenol 3G Summary

Significant technology advancements of the new UOP Phenol 3G process, we achieved:

- Reduction of **NCOP by up to $38/MT** in phenol production
- Increase of up to **$49MM in NPV** for a world class 300 KMTA unit

Through equipment metallurgy optimization, novel decomposer technology, and use of new and innovative fractionation technology for phenol fractionation, we achieved:

- Reduction in EEC (~13%)
- Reduction of steam consumption (at least 17%)
- Lower cumene/CHP inventory (60% lower in oxidation section)
- Reduced waste water (50%) are driven by improvements

The above benefits can be achieved while maintaining the **lowest cumene consumption** in the industry (lowest ton cumene/ton phenol) and **outstanding safety/ reliability/ operability** that the industry has come to know.

UOP Phenol 3G is the Best In Class for the Phenol Industry Today!


Q&A