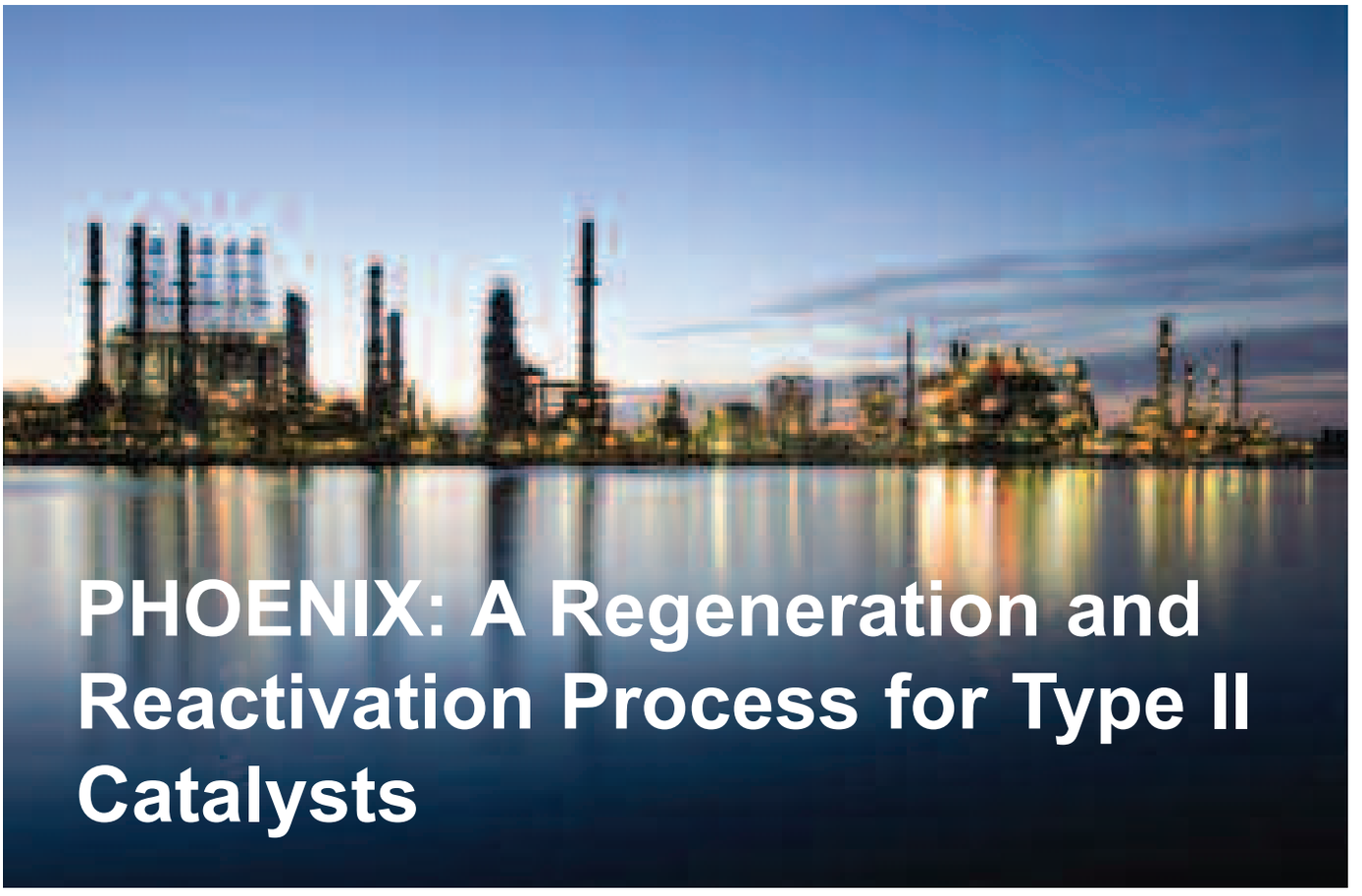

PHOENIX: A Regeneration and Reactivation Process for Type II Catalysts

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Type II catalysts have found wide application in a variety of hydrotreating applications especially ultra low sulfur diesel and hydrocracking pretreat units. ART offers a range of Type II catalysts built on the DX® technology platform which includes CDXi, 420DX CoMo catalysts; and NDXi, 590DX NiMo catalysts. The high activity of these catalysts is due in part to the unique chelate technology employed in their manufacture, a description of which can be found in Davison *Catalagram*® No. 96, 2004.

One of the issues with these types of catalysts is a high loss of activity after a conventional

Figure 17
Catalyst Activity After Regeneration

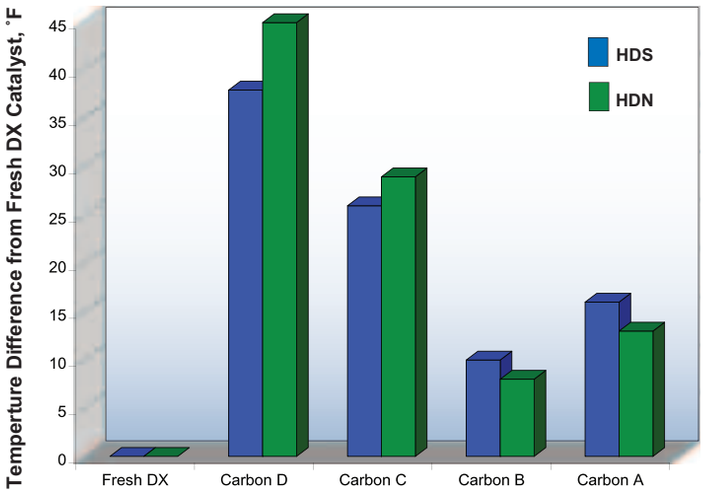
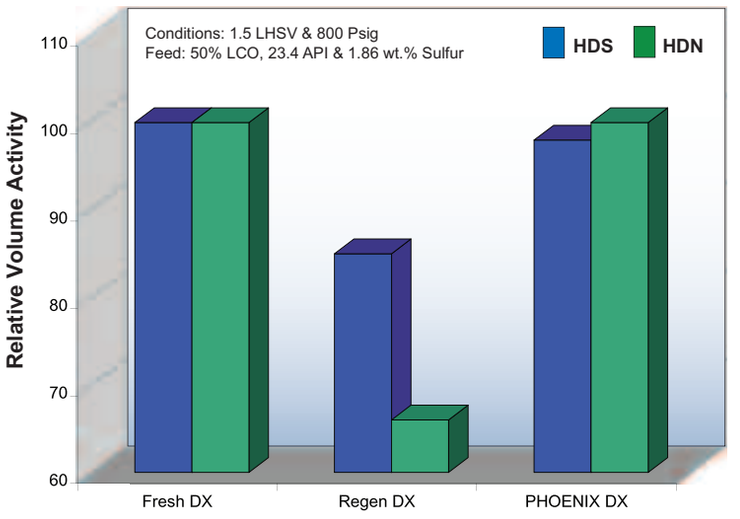


Figure 18
PHOENIX Restores Activity to Fresh Levels



regeneration. Type II catalysts typically recover only 70-80% of fresh catalyst activity following a conventional regeneration. At that activity level the catalysts are suitable for cascading to less demanding applications, but are not active enough to reuse in ULSD or hydrocracking pretreat units.

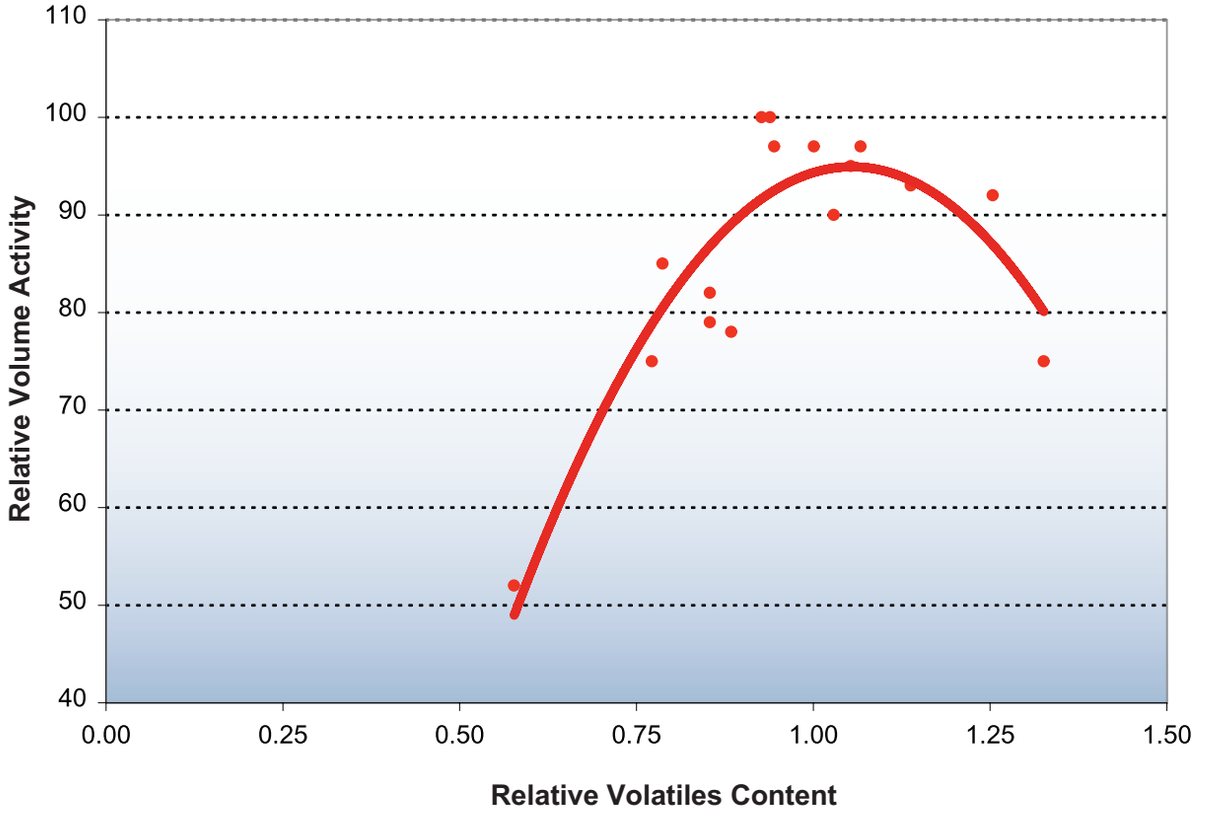
Figure 17 compares the activity of a series of DX catalysts which have been carefully regenerated to different carbon levels using conventional techniques.

Regeneration to low carbon levels still only results in a catalyst which has 10-15°F lower activity compared to fresh DX catalyst. This indicates over-regeneration in an effort to remove nearly all of the carbon results in no gains in catalyst performance with an increase in regeneration expense.

To address the issue of catalyst reuse, ART developed the PHOENIX™ process, a proprietary technology to restore DX and other catalysts with Type II functionality to near fresh activity. It involves a controlled regeneration followed by a proprietary re-activation which results in 90-95% of fresh catalyst activity recovery. Figure 18 compares the activity of Fresh and PHOENIX DX catalyst. In this case the catalyst was restored to within 95%+ of fresh catalyst activity.

ART has worked with TRICAT to scale up this technology to commercial scale. The PHOENIX process overview includes screening and segregating the spent catalyst to remove support media and oversize/undersize material prior to regeneration.

Figure 19
Optimization is Key to High Activity Recovery



Lot retains are collected and analyzed for a variety of contaminants, and the particle size distribution and physical properties are also determined to make sure the catalyst is suitable for reuse. Once the catalyst is approved for regeneration, it is processed in TRICAT's patented ebullated bed regeneration process. With this process the target carbon and sulfur levels can be achieved in a single pass with 15-18% lower attrition relative to other processes.

Once regenerated, the catalyst goes through the reactivation process which involves the application of nanoscale redispersents and a carefully controlled drying step. It is critical that the correct amount of redispersing agent is used for optimum activity, and further, it is important that the catalyst is dried properly. A catalyst which has excess redispersing agent after drying will perform poorly as will one with too little. This is demonstrated in Figure 19 which shows how sensitive catalyst activity is to the amount of redispersing agent.

Commercial scale reactivation via PHOENIX has been demonstrated for the DX™ catalyst platform in TRICAT facilities. Figure 20 compares the activity of fresh CDXi, a lab prepared PHOENIX CDXi and a commercial PHOENIX CDXi. The activity recovery of the PHOENIX samples are within 95% of the fresh catalyst activity. This process has been repeated in several commercial runs of the PHOENIX process using CDXi.

Figure 20
CDXi Has Been Successfully Reactivated

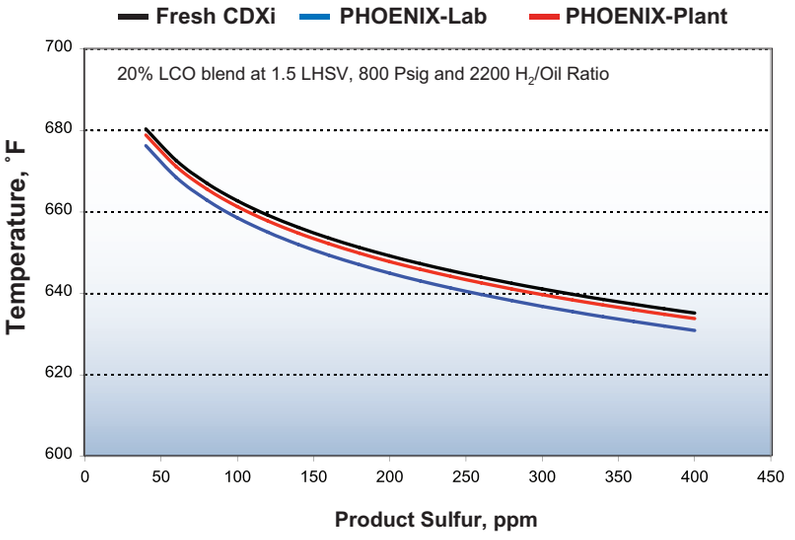
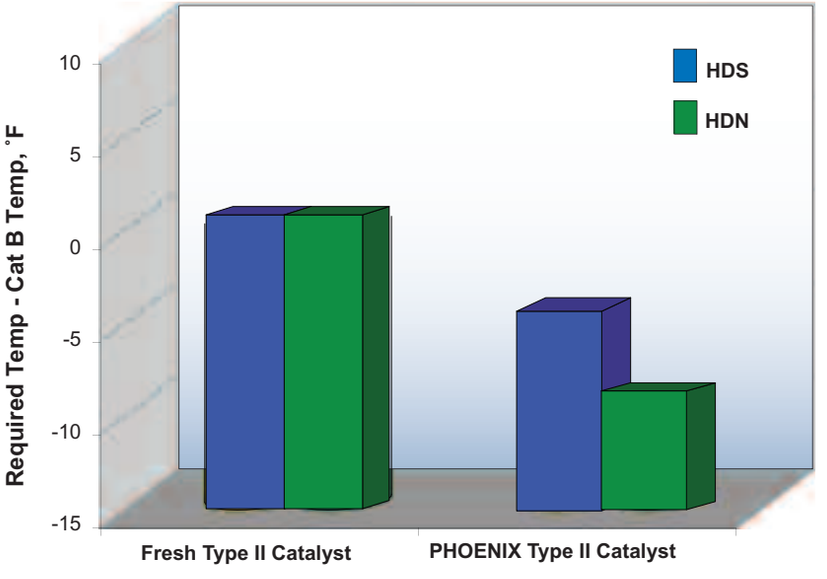


Figure 21
PHOENIX is Effective on a Variety of Catalysts



The PHOENIX process has also been applied to other Type II catalysts. Figure 21 compares the activity of a fresh Type II catalyst with the PHOENIX catalyst. The activity of the PHOENIX catalyst again exceeds 95% of fresh activity providing a viable option for catalyst restoration.

TRICAT has been approved for use of the PHOENIX process, and it has been proven commercially for both DX and several other Type II catalysts at TRICAT facilities. Activity recovery has easily met the 90-95% of fresh activity target in all cases so far. For details on how this process may apply to your spent Type II catalyst, please contact either TRICAT or ART to discuss how the PHOENIX process can bring back life to your regenerated catalyst inventory.