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# Conoco

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## CDR® 102

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### Flow Improver

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Headquarters and Domestic Sales Office  
Conoco Specialty Products Inc.  
5 Greenway Plaza East  
Suite 3034  
P.O. Box 2197  
Houston, TX 77252  
(713) 965-1767  
TELEX 775347  
TWX 910-881-2557

International Sales Offices  
Europe, Middle East, Africa  
Conoco Specialty Products  
A Division of SECA N.V.  
58, Boulevard du Regent  
Box No. 5  
1000 Brussels, Belgium  
(32-2)-513-1944, 513-1943  
TELEX 65851 SPEPRO

Pacific and Far East  
Conoco Specialty Products Inc.  
c/o Du Pont Far East, Inc.  
Box 1718 MCC  
Makati Metro Manila, The Philippines  
(63-2)-818-9911  
TELEX DUPHIL PN 63727

Latin America  
Conoco Specialty Products Inc.  
5 Greenway Plaza East  
Suite 3034  
P.O. Box 2197  
Houston, TX 77252  
(713) 965-1767  
TELEX 775347  
TWX 910-881-2557

Technical Sales Laboratory  
Conoco Specialty Products Inc.  
1000 South Pine  
P.O. Box 1267  
Ponca City, OK 74603  
(405) 767-3682  
TELEX 747171



Conoco Specialty Products Inc.

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Baker Hughes Incorporated

**Exhibit 1028**

BAKER HUGHES v. LUBRIZOL

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## CDR® 102

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### Flow Improver

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#### General Information:

Conoco's CDR® 102 Flow Improver is a second-generation, high-performance product used in pipelines to reduce turbulence and improve the flow characteristics of crude oil or hydrocarbon products. CDR is a solution of high molecular weight hydrocarbon polymer in a hydrocarbon solvent, and is effective at low concentrations (see *Figure 1*). Actual performance will depend on the hydraulic characteristics of the pipeline and the physical properties of the liquid.

CDR 102 is injected directly into the flowing product on the output side of the pipeline booster pump. It can be used to decrease energy loss due to turbulence and increase product throughput at constant pressure or, conversely, allow throughput to remain constant at reduced pressure.

#### Application:

Physical expansion is often the preferred solution to pipeline transportation problems. However, there are many cases where CDR offers pipeline operators a practical and more cost-effective alternative to physical expansion.

1. CDR can help alleviate bottlenecks in one or more pipeline segments.
2. CDR can be used in situations where increased throughput is desired, but physical expansion cannot be economically justified.
3. CDR can be used in areas where physical expansion is difficult to accomplish due to geographic or environmental problems. Examples are undersea pipelines, and pipelines in jungle or arctic regions.
4. CDR Flow Improver can be used to immediately increase pipeline product throughput in situations where physical expansion cannot be accomplished within the desired time frames.
5. CDR can be used to overcome temporary or short-term flow problems, such as the 2-3 year peak production periods of certain oil fields or applications where extra capacity requirements are seasonal or sporadic.
6. CDR Flow Improver can be used as an alternative to appropriation of capital equipment funds.
7. In some cases, the use of CDR will allow construction of downsized, less-expensive pipeline systems to satisfy specified throughput requirements.
8. CDR can be used in product lines to handle seasonal and other variable market demands. Products in which CDR has been used successfully are gasoline, diesel, LPG, and NGL.

#### Performance:

CDR works in the flowing liquid by reducing turbulence. By reducing the amount of energy normally lost to turbulent flow, CDR effectively increases pumping efficiency. The increased efficiency is measured as increased flow and decreased pressure drop at constant pumping power or, conversely, by reduced pressure at constant flow. Drag reduction is defined in Formula 1 as the difference in pressure drop along a segment of pipeline between pumping untreated fluid and pumping fluid containing CDR at a constant flow rate.

#### Formula 1

$$\% \text{ Drag Reduction} = \frac{\text{Pressure Drop, untreated} - \text{Pressure Drop with CDR}}{\text{Pressure Drop, untreated}} \times 100$$

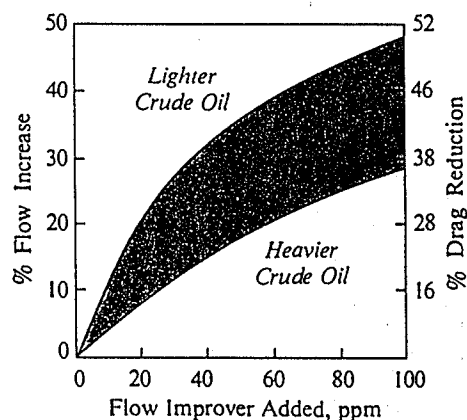
Flow increase may then be calculated using Formula 2 (this assumes a relatively constant pump efficiency).

#### Formula 2

$$\% \text{ Flow Increase} = \left[ \left( \frac{1}{1 - \frac{\% \text{ Drag Reduction}}{100}} \right)^{0.55} - 1 \right] 100$$

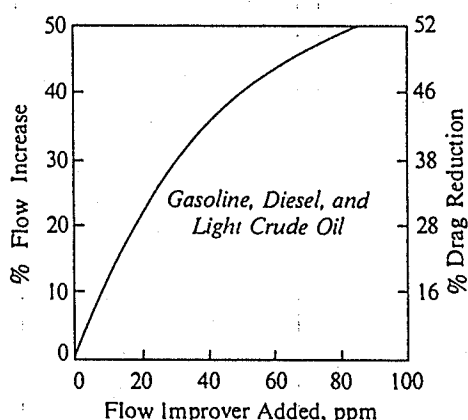
**Figure 1**  
Effect of CDR 102 Flow Improver  
Concentration on Flow Improvement

(Large Diameter Pipelines at 8 Ft./Sec.)



**Figure 2**  
Effect of CDR 102 Flow Improver  
Concentration On Flow Improvement

(Large Diameter Pipelines at 8 Ft./Sec.)



CDR has been tested in pipelines ranging from 3/8 inch (0.95 cm) diameter test loops to the very largest crude oil pipelines. These tests have proven the trouble-free performance of CDR in pipelines and have defined the parameters which affect the performance of CDR.

**Concentration.** The impact of CDR® 102 Flow Improver concentration on flow increase is presented in *Figures 1 and 2* at a constant pipeline velocity of 8.0 ft/sec (2.44 m/sec) for crude oils and petroleum products such as gasoline, diesel, and LPG. Drag reduction (or flow increase at constant pressure) increases with the polymer concentration.

**Fluid Velocity.** The effectiveness of CDR increases with increasing fluid velocity. This is because CDR reduces the amount of energy lost to turbulence. As fluid velocity increases, turbulence increases, and the effectiveness of CDR increases.

**Fluid Viscosity.** Also indicated in *Figures 1 and 2* is the dependence of CDR performance on fluid viscosity. CDR is more effective in low viscosity light crudes and petroleum products than in high viscosity or "heavy" crudes. At a constant velocity, the flow of a light crude is more turbulent than that of a heavy crude, and reduction of turbulence by CDR is more pronounced. However, CDR has been found to be commercially effective in crude gravities as low as 23° API.

**Pipeline Diameter.** The data in *Figures 1 and 2* should be applicable to pipelines 8 inches (20.3 cm) in diameter and larger. In lines smaller than 8 inches (20.3 mm) in diameter, the drag reduction performance of CDR tends to increase with decreasing diameter. Thus, smaller lines and laboratory loops may show higher drag reductions for given CDR concentrations than are indicated in the *Figures*.

**Mechanical Shear.** No degradation of CDR is observed during normal pipeline flow. However, when the treated liquid passes through regions of high shear, such as centrifugal pipeline booster pumps, the drag-reducing properties of the polymer are greatly diminished.

Because CDR works by reducing turbulence in the flowing liquid, it must be added continuously. (It does not coat the pipeline wall.) Drag reduction begins as soon as injection of CDR begins and increases in magnitude until all liquid in the pipeline segment being treated contains CDR. At that point, drag reduction will remain constant at constant CDR injection rates. When injection of CDR is stopped, drag reduction immediately declines as untreated liquid displaces treated material in the pipeline. Drag reduction continues to decline until all treated liquid has left the pipeline, at which point the original flow condition of the line is reestablished.

#### Downstream Effects:

##### Crude Oil

The effect of CDR on crude oil pipelines has been extensively tested in the laboratory as well as in full-scale refinery tests as has the effect of residual CDR in the crude oil on refinery processes. CDR presents no handling or processing problems in either case.

##### Petroleum Products

Extensive testing has been conducted to show that CDR does not affect the results of fuel specification tests for gasoline, diesel, and LPG fuels. Also, automobile road tests and laboratory engine tests have been performed for both gasoline and diesel fuel. CDR has no detrimental effect upon the life or performance of engines.

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**Properties:**

CDR is a very thick, viscous, non-Newtonian liquid (apparent viscosity decreases as shear rate increases). Some important physical properties are presented in Table I. Although CDR is very viscous, transfer or injection can be readily accomplished using the appropriate equipment.

Table I

	Typical Properties of CDR 102 Flow Improver	
	>142	>(61.1)
Flash Point, °F (°C)		
Density, Lb./U.S. Gal. (Kg/Liter)	6.8	(0.814)
Ash, total, wt. %	0.19	

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**Injection:**

Injection of CDR into a pipeline is a straightforward mechanical process. Suitable injection pumps are available "off-the-shelf" in a wide range of capacities. These should be used with a standard variable speed drive and an accurate flow indicator for close control of injection rates.

Additional information and assistance in the design and procurement of injection equipment can be provided, when appropriate, on request.

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**Technical Assistance:**

Conoco personnel are experienced in analyzing specific applications and advising the feasibility of CDR 102 Flow Improver on a cost/performance basis. They can also assist in all phases of product evaluation and testing, from laboratory screening to full-scale injection tests.

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**Availability:**

CDR is available from the Conoco Specialty Products Inc. production facility at Lake Charles, Louisiana. Transportation is offered by rail tank car, tank truck or pressurized bulk containers (45 psi) in sizes ranging from 700 to 5,000 gallons. Both bulk containers are IMCO and IATA approved for air and sea transportation.

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**Inquiries:**

All inquiries should be directed to the Vice President of Marketing, Conoco Specialty Products Inc., Houston, Texas, or to the nearest international sales office. Inquiries will be held in strict confidence.

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**Storage and Handling:**

Specific storage and handling information as well as Material Safety Data Sheets for CDR are available on request. CDR is classified as a combustible liquid; its flash point is above 142°F. It should be kept away from heat or open flame. It can cause skin and eye irritation, so care should be taken to avoid contact with eyes or the skin.

Spills can be cleaned up by treatment with an all-purpose grease and oil absorbant followed by mechanical collection of the CDR-absorbant mass and disposal at an EPA-approved waste disposal site. Detailed spill clean-up procedures are available on request.

Please refer to the Conoco Specialty Products Inc. Material Safety Data Sheet for specific, complete information regarding this product.



Conoco Specialty Products Inc.

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