MATROSTECH
www.matrostech.com
Matros Technologies, Inc.
14963 Green Circle Dr.
St. Louis, MO 63017
Tel. 314-426-8820
Fax. 314-426-8620
e-mail: info@matrostech.com
ALVIGO
www.alvigo.ee

ALVIGO-MATROS CATALYSTS

MATROS TECHNOLOGIES, INC. is pleased to introduce a portfolio of high-performance catalysts produced for chemical industries, developed and manufactured by **ALVIGO**, our partners in Russia.

Matros Technologies, Inc. has been established in 1993 as a chemical process engineering, R&D, and consulting company. Before that, our team has been involved in academic and industrial R & D in the area of catalytic reactor technology for about 30 years. We have been the first to develop the reversed-flow reactor (RFR) technology in the 70s. From the beginning, Matros Technologies has been supplying process solutions and engineering services in areas such as thermal and catalytic VOC oxidation, selective catalytic reduction of NOx, synthesis of formaldehyde, and a number of other processes. With the help of sophisticated catalyst testing equipment and process simulation software, we design and optimize catalytic processes helping our customers to increase productivity sand/or reduce costs. Among our satisfied customers are General Motors, Ford, and Monsanto.

ALVIGO operates primarily in post-Soviet countries, supplying catalysts and a full range of support and services related to catalysts and reactors used in the production of syngas, hydrogen, ammonia, and methanol. Its close ties with NIAP – a scientific and technical leader in catalysts and process technology – ensures ready availability of highly qualified experts possessing knowledge, testing equipment, and software to help them solve even the most complicated problems.

With a foundation in decades long Russian scientific tradition, unparalleled knowledge of our scientists and engineers, ISO 9001 compliant quality management system implemented by our manufacturer plants, excellent customer service, and total annual output of 6,000 tons, we are able to meet the needs of the most demanding customers.

We now offer catalysts for a wide range of processes including:

- sulfur removal by absorption,
- hydrodesulfurization,
- primary reforming,
- secondary reforming,
- high temperature shift reaction,
- low temperature shift reaction,
- methanation,
- ammonia synthesis,
- methanol synthesis.

Combination of expertise and resources of both companies creates the capability to provide for consulting services and assistance in operation of your company's plant. At this moment, our scope of services includes:

Catalyst Testing

Matros Technologies and Alvigo provide the customers access to a wide range of catalyst testing and characterization capabilities, including:

Activity

Surface science methods for in-depth look at the state of the catalyst surface

Mechanical strength

Chemical composition

Surface area and other structural parameters

Process Evaluation

Based on the catalyst test data, and using sophisticated process simulation software, we are able to determine optimum process conditions and to issue recommendations on complete or partial catalyst replacement.

We are ready to set up a service program aimed at evaluating the state of the catalyst in each of the process units based on operating parameters measured by the plant.

Lifetime Prediction

Using operating history of the catalyst, we can accurately forecast the expected catalyst life, and develop an optimum turnaround schedule.

Catalyst Selection

We recognize very well that each plant is unique, and we intend to work closely with you to learn as much as possible about your plants and to develop catalyst solutions tailored specifically for your equipment and operating conditions. We will provide all information necessary for you to take an informed decision on what catalyst would do the best job.

Troubleshooting

We have a team of highly qualified experts who will be engaged when needed to solve your operating problems, both in our offices and at your site.

Plant Operator Training

We will provide training courses for your corporate and plant personnel, focused on our catalyst technology, properties, and operating conditions and guidelines.

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PURIFICATION OF GASES FROM SULFUR COMPOUNDS

Zn and Zn-Cu absorbents of **SPS-F** and **NIAP-02** are designed for fine purification of natural, coke-oven and other process gases from sulfur compounds. The absorbents incorporate the results of extended research and development focused on a) development of superfine active zinc oxide, and b) formation of mechanically strong extruded particles with optimal pore structure that ensures superior dynamic characteristics and stability.

	SPS-FZ	**SPS-FP**
Appearance	Light-gray cylinders	Dark-gray cylinders
Chemical composition, %		
ZnO	90	80
CuO	-	10
Bulk density, g/cm^3	1.3	1.3
Diameter, inch	5/32 – 15/64 (4 – 6 mm)	5/32 – 15/64 (4 – 6 mm)
Mechanical (crushing) strength, N	150	150

Operating conditions:

Pressure	up to 730 psig (5 MPa)
Temperature	660 – 790 °F (350 - 420 °C) (SPS-FZ),
	480- 790 °F (250 - 420°C) (SPS-FP),
Space velocity	up to 1,700 h^{-1},
Hydrogen sulfide concentration	up to 50 ppm (80 mg/m3).

Copper-promoted **SPS-FP** and **NIAP-02-03** absorbents provide for a reduction in operating temperature down to 480 °F (250 °C) while keeping the same or better desulfurization efficiency. They can effectively operate with reduced hydrogen feed, as well as remove organo-sulfur compounds.

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	NIAP-02-03	**NIAP-02-05**
Appearance	Light-green cylinders	Gray-white cylinders
Chemical composition, %		
ZnO	77	90
MgO	3.5	5 – 8
CuO	9 – 11	-
Bulk density, g/cm^3	1.4	1.2
Diameter, inch (mm)	9/64 – 7/32 (3.5 – 5.5)	9/64 – 7/32 (3.5 – 5.5)
Mechanical (crushing) strength, N	170	170

Operating conditions:

Pressure	up to 600 psig (4 MPa)
Temperature	480 – 660 °F (250 - 350 °C),
Space velocity	700 – 1,300 h^{-1},
Hydrogen sulfide concentration	up to 50 ppm (80 mg/m3),
Hydrogen concentration	4 – 11 % vol.

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HYDRODESULFURIZATION OF NATURAL AND REFINERY GASES

Al-Co-Mo and Al-Ni-Mo catalysts of **GPS** and **NIAP-01** series are used for hydrogenation of sulfur compounds found in natural gas and refinery gases used as feedstocks for ammonia, methanol and hydrogen production. The catalysts possess high efficiency while requiring low loadings, and operate effectively under conditions of drastic changes in sulfur content of the feedstock.

GPS-1F and **GPS-3Sh** are Al-Ni-Mo catalysts characterized by high hydrodesulfurization and hydrogenation activity and recommended for use at higher content of nitrogen containing organic compounds, olefins and carbon oxides in the feedstock. **GPS-2F** and **GPS-4Sh** are Al-Co-Mo catalysts that provide for even higher than **GPS** types hydrodesulfurization activity.

All **GPS** catalysts possess excellent mechanical strength and catalytic activity, achieved at low content of active components due to optimal, "egg-shell" type distribution of active components in the pellet.

	GPS-1F	GPS-2F	**GPS-3Sh**	**GPS-4Sh**
Appearance	Extruded cylinders		Spheres	
Chemical composition, %				
MoO_3	8 – 12		8 – 12	
NiO	2 – 3	-	2 – 3	-
CoO	-	2 – 3	-	2 – 3
Bulk density, g/cm^3	0.7		0.8	
Diameter	9/64 – 7/32 (3.5 – 5.5)		9/64 – 7/32 (3.5 – 5.5)	
Mechanical (crushing) strength, N	80	80	140	140
Operating conditions:				
Pressure	up to 730 psig (5 MPa)			
Temperature	480 - 750 °F (250 - 400 °C),			
Space velocity	up to 2,500 h^{-1},			
Inlet concentration of sulfur compounds	up to 25 ppm (40 mg/m3).			
Added hydrogen concentration	2 to 10 % vol.			

	NIAP-01-01	**NIAP-01-03**
Appearance	Light-gray extrudates	
Chemical composition, %		
CoO	3.5	-
CoO or NiO	-	3.0
MoO_3	11	9.5
Bulk density, g/cm^3	0.8	0.8
Diameter, inch (mm)	9/64 – 7/32 (3.5 – 5.5)	9/64 – 7/32 (3.5 – 5.5)
Mechanical (crushing) strength, kg/mm	1.2	1.4
Operating conditions:		
Pressure	up to 730 psig (5 MPa)	
Temperature	340 - 400 °C,	
Space velocity	500 – 2,000 h^{-1},	
Inlet concentration of sulfur compounds	up to 25 ppm (40 mg/m3).	
Added hydrogen concentration	2 to 10 % vol.	

PRIMARY STEAM REFORMING

Choice of an optimum catalyst depends on many factors, such as furnace design, type of feedstock, steam to carbon ratio, etc. Therefore, we offer several types of catalysts that feature different carriers, shape and chemical composition.

NIAP-18, **NIAP-03-01**, **K-905-D1**, **K-87-3** incorporate promoted nickel oxide deposited on refractory porous support. They are produced for steam and steam/carbon dioxide conversion of gaseous and liquid hydrocarbons in multitubular reformer furnaces.

	NIAP-18
Appearance	Gray or light-gray cylindrical pellets
Chemical composition, %	
NiO	10 -12
Bulk density, g/cm^3	1.0
Size, inches	9/16 x 15/32 x ¼ (14.5 × 12 × 6.5 mm)
Mechanical (crushing) strength, N	500
Operating conditions:	
Pressure	up to 500 MPa
Furnace outlet temperature	1380 – 1560 °F (750 - 850 °C),
Space velocity	1,500 – 1,800 h^{-1},
Steam : gas ratio	2.9 – 4.0

NIAP-03-01. Optimized pellet shape and size of this catalyst provides for:

- high specific activity of the catalyst bed due to increased surface of the granules and their stability during operation;
- high bed porosity and low pressure drop;
- minimum temperature of tubes' walls due to improvement of radial heat exchange in tubes;
- perfect flowability of catalyst granules, which increases compactness of loading.

- The improved catalyst pore structure provides:
- increase of catalyst activity and catalyst life time;
- increase of thermal stability of active component.

These advantages allow for extending the service life of catalyst and tubes, increased productivity of the furnace, and decreased energy consumption.

NIAP-03-01 has high thermal stability, and withstands more than 20 thermal shocks (1,000 °C - air) without crushing. The catalyst does not contain silicon, thus eliminating problems related to its migration.

	NIAP-03-01
Appearance	Gray or light-gray cylinders with 7 holes
Chemical composition, %	
NiO	11
Bulk density, g/cm^3	1.0
Size, inches	9/16 x 35/64 (14.5 × 14 mm)
Mechanical (crushing) strength, N	500

Operating conditions:	
Pressure	up to 580 psig (4.0 MPa)
Furnace outlet temperature	1380 – 1560 °F (750 - 850 °C),
Space velocity	up to 2,000 h^{-1},
Steam : gas ratio	2.9 – 4.0

Promoted by lanthanum, **K-905-D1** and **K-87-3** catalysts are highly resistant to coke formation in primary reformers.

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	K-905-D1	K-87-3
Appearance	Gray Rashig rings	Gray cylinders
Chemical composition, %		
NiO	10 – 12	10 – 12
Promoters	3	3
Al_3O_3	Balance	balance
Bulk density, g/cm^3	1.0	1.2
Size, inches	5/8 x 5/8 x 15/64 (16 × 16 × 6 mm) *	19/32 x 19/32 (15 × 15 mm)
Mechanical (crushing) strength, N	750	750

*Depending on the reformer design, other sizes are available

Operating conditions:

Pressure	up to 580 psig (4.0 MPa)
Furnace outlet temperature	1,650 °F (900 °C),
Space velocity	up to 2,000 h^{-1},
Steam : gas ratio	2.9 – 5.0 (2.0 – 3.5 for steam / CO_2 conversion)

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SECONDARY REFORMING

Nickel catalysts NIAP-03-01, NIAP-20, NIAP-20-01, K-905-D2, NIAP-22V, GIAP-3-6H, GIAP-8S, and GIAP-14S are used in autothermal and secondary reforming processes.

While designed for primary reforming process, **NIAP-03-01** catalyst can be used for secondary reforming, especially in larger ammonia plants, (1,700 TPD or more). Due to high activity of the catalyst, reduced loading is required. An increase in free space above the catalyst bed allows for prevention of local overheating of the catalyst in the upper part of converter.

NIAP-20-01, **NIAP-20** and **K-905-D2** catalysts are offered as mainstream catalysts for secondary reforming process. The products ensure high productivity, low pressure drop, and long operational life in shaft converters of large plants.

	NIAP-20	NIAP-20-01
Appearance	Gray or light gray Rashig rings	
Chemical composition, %		
NiO	8	11
CaO	8 – 10	8 – 10
Al_3O_3	Balance	balance
Bulk density, g/cm^3	1.0	1.2
Size, inches	49/64 x 9/16 x 11/32	9/16 x 15/32 x 1/4
	(19.5 × 14. × 8.5 mm)	(14.5 × 12 × 6.5 mm)
Mechanical (crushing) strength, N	500	500

Operating conditions:

Pressure	up to 500 psig (3.5 MPa)
Furnace outlet temperature	1740 – 1830 °F (950 - 1,000 °C),
Space velocity	1,000 – 1,300 h^{-1},
Air : gas ratio	1.43 – 1.44

Sometimes, it is recommended to combine **NIAP-20**, **NIAP-20-01**, **K-905-D2** and **NIAP- 03-01**.

	K-905D-2
Appearance	Gray Rashig rings
Chemical composition, %	
NiO	8 – 10
Bulk density, g/cm^3	1.0
Size, inches	5/8 x 5/8 x 15/64 (16 × 16 × 6 mm) *
Mechanical (crushing) strength, N	500

*Depending on the reformer design, other sizes are available

Operating conditions:

Pressure	up to 500 psig (3.5 MPa)
Furnace outlet temperature	1,740 – 1,830 °F (950 - 1,000 °C),
Space velocity	1,000 – 1,300 h^{-1},
Air : gas ratio	1.43 – 1.44

When there are no strict requirements to pressure drop, conventional nickel catalysts for secondary reforming **GIAP-3-6N**, **GIAP-8S** and a protective layer of Al-Cr catalyst **GIAP-14S** are offered.

	GIAP-3-6N	**GIAP-8S**
Appearance	Gray rings	Gray cylinders
Chemical composition, %		
NiO	6 – 9	6 – 10
Al_3O_3	balance	Balance
Bulk density, g/cm^3	1.4	1.2
Size, inches	19/32 x 19/32 x 5/32 (15 × 15 × 4 mm)	19/32 x 19/32 (15 x 15 mm)
Mechanical (crushing) strength, N	750	750

Operating conditions:

Pressure	up to 580 psig (4 MPa)
Temperature	up to 2,200 °F (1,200 °C),
Space velocity	up to 4,000 h^{-1},

	GIAP-14S
Appearance	Grey-green cylinders
Chemical composition, %	
Cr_2O_3	5 – 8
Al_2O_3	Balance
Bulk density, g/cm^3	1.2
Size, inches	19/32 x 19/32 (15 × 15 mm)
Mechanical (crushing) strength, N	600

Operating conditions:

Pressure	up to 580 psig (4 MPa)
Temperature	up to 2,300 °F (1,250 °C),

NIAP-22V, which does not contain chrome is preferable for use in the protective layer.

	NIAP-22V
Appearance	Cylinders with 6 holes and convex butts
Chemical composition, %	
NiO	6 – 8
Al_2O_3	Balance
Bulk density, g/cm^3	1.0
Size, inches	1–3/16 x 1–3/16 (30 × 30 mm)
Mechanical (crushing) strength, N	800

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Operating conditions:

Pressure	up to 580 psig (4 MPa)
Temperature	up to 2,300 °F (1,250 °C)

Depending on requirements of plant operation and the composition of converted gas, we propose optimized, combined catalysts loadings that provide for minimal pressure drop over catalysts bed with the lowest methane content at the outlet.

HIGH TEMPERATURE CO CONVERSION

Four types of catalysts are produced for high temperature CO steam conversion (High Temperature Shift). The catalysts differ in shape, pellet size, and chemical composition. Along with conventional **STK-1**, promoted **STK-SF**, Fe-Cr **STK-SMT** and **STK-SMF** are offered, that do not need desulfurization. The catalysts have high activity due to promotion by copper, can operate at low temperatures, low steam : gas ratio, decreased catalysts loads. The choice of catalyst depends on particular features of the plant.

	STK-SMT	STK-SMF	**STK-1**	**STK-SF**
Appearance	Tablets	Extruded cylinders		
Chemical composition, %				
Fe_2O_3	96	99	92	88
Cr_2O_3	8	8	8	8
CuO	2	2	-	-
Promoters	-	-	-	4
Bulk density, g/cm^3	1.2	1.3	1.3	1.3
Size, inches	11/32 x 15/64 or 15/64 x 13/64 (9 × 6 or 6 × 5 mm)	Diameter 13/64 or 9/32 (Diameter 5 or 7 mm)		
Mechanical (crushing) strength, N	300 or 200	200 or 300		

Operating conditions:

Pressure	up to 580 psig (4 MPa)
Temperature	600- 930 °F (315 - 500 °C),
Space velocity	up to 4,000 h^{-1},
Steam : gas ratio	0.4 – 0.8

STK and STK-SMF are designed for operation in ammonia plants at lower inlet temperatures of 595 – 615 °F (314 – 325 °C) while STK-SF is used at inlet temperature of 615 – 645 °F (325 – 340 °C).

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LOW TEMPERATURE CO CONVERSION

SNK- 2 is a Cu-Zn-Al co-precipitated catalyst for low temperature shift, having high activity and providing for minimal methanol formation.

	SNK-2
Appearance	Black cylinders or tablets
Chemical composition, %	
CuO	43
ZnO	43
Al_2O_3	11
Bulk density, g/cm^3	1.3
Size, inches (mm)	15/64 x 5/32 (6 × 4 mm) or 13/64 x 13/64 (5 × 5 mm)
Mechanical (crushing) strength, N	130
Operating conditions:	
Pressure	up to 580 psig (4 MPa)
Temperature	360 – 570 °F (180 - 300 °C),
Space velocity	up to 5,000 h^{-1},
Steam : gas ratio	0.4 – 0.8

NIAP-06 catalysts comprise copper, zinc and aluminum compounds with addition of a special cement that adds strength to catalyst pellets after hydrothermal hardening.

NIAP-06-04 is designed for use in the primary bed, while **NIAP-06-03** is loaded in the front layer to protect primary catalyst from destruction caused by moisture condensation and from sulfur poisoning.

	NIAP-06-03		**NIAP-06-04**	
Appearance	Dark gray to light green cylindrical pellets			
Chemical composition, %				
CuO	23 – 31		45 - 51	
ZnO	36 – 44		20 - 25	
Al_2O_3	19		17	
CaO	5 – 11		4 – 10	
Bulk density, g/cm^3	1.2		1.2	
Size, inches (mm)	13/64 (5.0)	9/64 (3.5)	13/64 (5.0)	9/64 (3.5)
Mechanical (crushing) strength, N	1.7	1.5	1.7	1.5

Operating conditions:

Pressure		up to 540 psig (3 MPa)
Temperature		NIAP-06-03: 390 – 680 °F (200 – 360 °C)
		NIAP-06-04: 365 – 680 °F (185 – 360 °C)
Space velocity		2,000 – 5,000 h^{-1},
Steam : gas ratio		0.4 – 0.8
Impurities, mo more than:	sulfur	0.15 ppm (0.2 mg/m^3)
	chlorine	0.03 ppm (0.05 mg/m^3)
Inlet CO concentration		2 – 5 % vol

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METHANATION

Nickel catalysts **NIAP-07-01**, **NIAP-07-02**, **TO-2M** are used for purification of hydrogen containing gases from carbon oxides by via hydrogenation to methane. Nickel content varies between 30 and 40% as NiO. These catalysts are the most active and reliable due to higher content of superfine nickel per unit volume. The catalysts withstand short-term overheating up to 550°C (**NIAP-07-02 -** up to 650°C) without activity loss, and ensure stable pressure drop throughout the entire lifetime.

	NIAP-07-01	NIAP-07-02	TO-2M
Appearance (all are cylindrical tablets)	taupe to black	taupe to black	dark-brown
Chemical composition, %			
Bulk density, g/cm^3	1.2	1.15	1.25
Size, inches	7/32 x 11/64 (5.5 × 4.5 mm)	7/32 x 3/8 (5.5 × 5.0 mm)	7/32 x 3/8 (5.5 × 5.0 mm)
Mechanical (crushing) strength, N	70	100	100
Operating conditions:			
Pressure, psig	290 – 4,000 (2 30 MPa)	290 – 4,000 (2 - 30 MPa)	15 – 4000 (0.1 – 30 MPa)
Inlet CO_x concentration, % vol.	0.3 – 1.3	0.3 – 2.5	< 2
Temperature, °F	355 – 840 (180 – 450 °C)		
Space velocity, h^{-1}	3,000 – 20,000		

If there is a need in purification from carbon oxides at low temperatures (150 °C at the outlet), ruthenium catalyst **RKM-3** catalyst is used.

	RKM-3
Appearance	Taupe or black pellets
Ru content, %	0.3
Bulk density, g/cm^3	0.9
Diameter, inches	3/32 – 1/8 (2.6 – 3.0 mm)
Mechanical (crushing) strength, N	120

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Operating conditions:

Pressure	up to 4,400 psig (30 MPa)
Temperature	300 °F (150 °C),
Space velocity	3,000 – 20,000 h^{-1},
Inlet CO_x concentration	up to 3 % vol.

AMMONIA SYNTHESIS

SA-S is our catalyst for ammonia production from nitrogen/hydrogen mixture. It is made of magnetite with an optimum mix of promoters. The catalyst can be supplied in pre-reduced form (**SA-SV**) and of various sizes: fine grain fractions (1.5 – 3 and 3 – 5 mm), coarse grain fractions (5 – 7, 7 – 10, and 10 – 15 mm).

	SA-S	**SA-SV**
Appearance	Irregular black or gray pellets	
Chemical composition, %		
K_2O	0.8 – 1.2	
Al_2O_3	2.4 – 3.8	
CaO	1.9 – 2.8	
SiO_2	less than 0.7	
Fe metal	-	72
Fe oxides	Balance	balance
Bulk density, g/cm^3	2.2	2.2
Size fraction, inches	1/16 x 1/8, 1/8 x 3/16, 3/16 x 1/4, 1/4 x 3/8, 3/8 x 5/8 (1.5 x 3, 3 x 5, 5 x 7, 7 x 10, 10 x 15 mm)	

Operating conditions:

Pressure	2,200 – 8,000 psig (15 – 55 MPa)
Temperature	750 – 1,100 °F (400 - 600 °C),
Space velocity	30,000 h^{-1},
Inlet CO_x concentration	up to 3 % vol.

The catalyst is prepared from a special, high purity raw material. The pressure drop through the catalyst bed remains constant during its entire lifetime. The catalyst has high and stable activity and is safe, as confirmed by hundreds of loadings during over 30 years of commercial application.

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SYNTHESIS OF METHANOL

SMS-4 is a Zn-Cr catalyst, conventionally used for high temperature methanol synthesis from syngas. Small pellet size (tablets with diameter 5-6 mm) provides for reduced diffusion resistance and plant productivity increase by 5-10%.

SNM-U is a Cu-Zn-Al new generation catalyst, manufactured using nitrate precipitation technology. The catalyst has very high activity and thermal stability that ensures long lifetime. High selectivity of **SNM-U** allows for producing a very high quality raw methanol, with substantial savings of raw materials and energy. Improved mechanical strength of the catalyst tablets allows for longer service life without destruction or an increase in the pressure drop through the reactor.

	SMS-4			
Appearance	Grey-yellow tablets			
Chemical composition, %				
ZnO	55 – 58			
Cr_2O_3	33 – 35			
Bulk density, g/cm^3	1.3 – 1.8			
Size, inches	11/32 x 5/16 (9 × 8 mm)	11/32 x 3/16 (9 × 5 mm)	9/32 x ¼ (7 × 6 mm)	3/16 x 3/16 (5 × 5 mm)
Mechanical (crushing) strength, N	200	150	150	120

Operating conditions:

Pressure	over 2,900 psig (20 MPa)
Temperature	610 – 750 °F (320 - 400 °C)

	SNM-U
Appearance	Black tablets
Chemical composition, %	
CuO	53
ZnO	26
Al_2O_3	5.5
Bulk density, g/cm^3	1.3
Size, inches	3/16 x 3/16 (5 × 5 mm) or 15/64 x 5/32 (6 × 4 mm)
Mechanical (crushing) strength, N	130

Operating conditions:

Pressure	up to 1,450 psig (10 MPa)
Temperature	390 – 570 °F (200 - 300 °C)