



Thermo Scientific Oil and Gas

# Petroleum and Natural Gas

## Analysis Workflows

- Gas Chromatography • Gas Chromatography Mass Spectrometry • Ion Chromatography
- Combustion Ion Chromatography • Inductively Coupled Plasma-Optical Emission Spectroscopy
- Elemental Analysis • Laboratory Information Management Systems
- Chromatography Data Systems

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SCIENTIFIC

# Petroleum and natural gas production

Oil, coal, natural gas. These and other fossil fuels are hydrocarbons from the remains of plants and animals that lived millions of years ago. Today, they power our world.

Upstream, midstream or downstream, the oil & gas industry is feeling the pressure to improve production efficiency. Whether it is the margin squeeze from falling crude prices, pressure to support expansion, or opportunity to take advantage of lower feedstock prices, every lab's work becomes just that much more important. So does the decision on who you choose to help you.

Analysis needs to get smarter, faster, more cost-effective. And the analytical instrumentation you choose is absolutely critical. From gas or ion chromatography to inductively coupled plasma mass spectrometry and elemental analysis. Ideally suited to satisfy your needs. Sample prep, columns, consumables. It's all here. Including the industry's leading integrated informatics to streamline laboratory processes, satisfy compliance processes, and improve overall facility (and multi-facility) performance.

It's all part of our philosophy that says as the world changes, the innovations we design in conjunction with our many users need to keep pace as well.

It's a philosophy that's led to innovations like the Thermo Scientific™ TRACE™ 1310 Series Gas Chromatograph (GC) with the remarkable simplicity of Instant Connect modules that let you replace a faulty detector in less than 30 minutes. On the spot. No service call, no trouble shooting, no lost hours.

These are changing times for our industry. And we're here to help you navigate whatever lies ahead with the products and support to get your job done.

## Oil & Gas Value Chain

Upstream

Midstream

Exploration



Production



Custody Transfer



Storage



Carbon number	1	2	3	4	5	6	10	16	20	30	44	60	80	120	
Boiling point	-200	-100	0	100	200	300	400	500	600	700	800				
ASTM D3710			gasoline												
ASTM D7096			gasoline + ethanol												
ASTM D5399			solvents												
ASTM D2887			petroleum fractions												
ASTM D5442							petroleum wax								
ASTM D7213						medium petroleum distillates									
ASTM D6417						medium petroleum distillates									
ASTM D6352						medium and heavy petroleum distillates									
ASTM D5307	crude petroleum														
ASTM D7500						medium and heavy petroleum distillates									
ASTM D7169	crude oil and residues														
DIN 51581-2						medium petroleum distillates									
DIN 51435						medium and heavy petroleum distillates									
IP 406						petroleum products									
IP 480						middle distillates and lubricating base oils									
IP 507						vacuum distillates and residues									
IP 545	crude oil														
EN 15199-1						middle distillates and lubricating base oils									
EN 15199-2						vacuum distillates and residues									
EN 15199-3	crude oil														
ISO 3924						petroleum fractions									
UOP 1001-14			F and Cl in LPG												
ASTM D7359			F, Cl, S in aromatic HC												
ASTM D5600												metals in coke			
ASTM D5185												metals in lube oils			
ASTM D5662			oxygen in gasoline and methanol												
ASTM D5291			C, H, N in petroleum products and oils												

■ GC, GC-MS  
 ■ CIC  
 ■ ICP-OES  
 ■ OEA

There are many standard methods in existence for various regulations covering a wide range of boiling point and application ranges.

## Downstream

Wholesale Marketing



Refining



Distribution

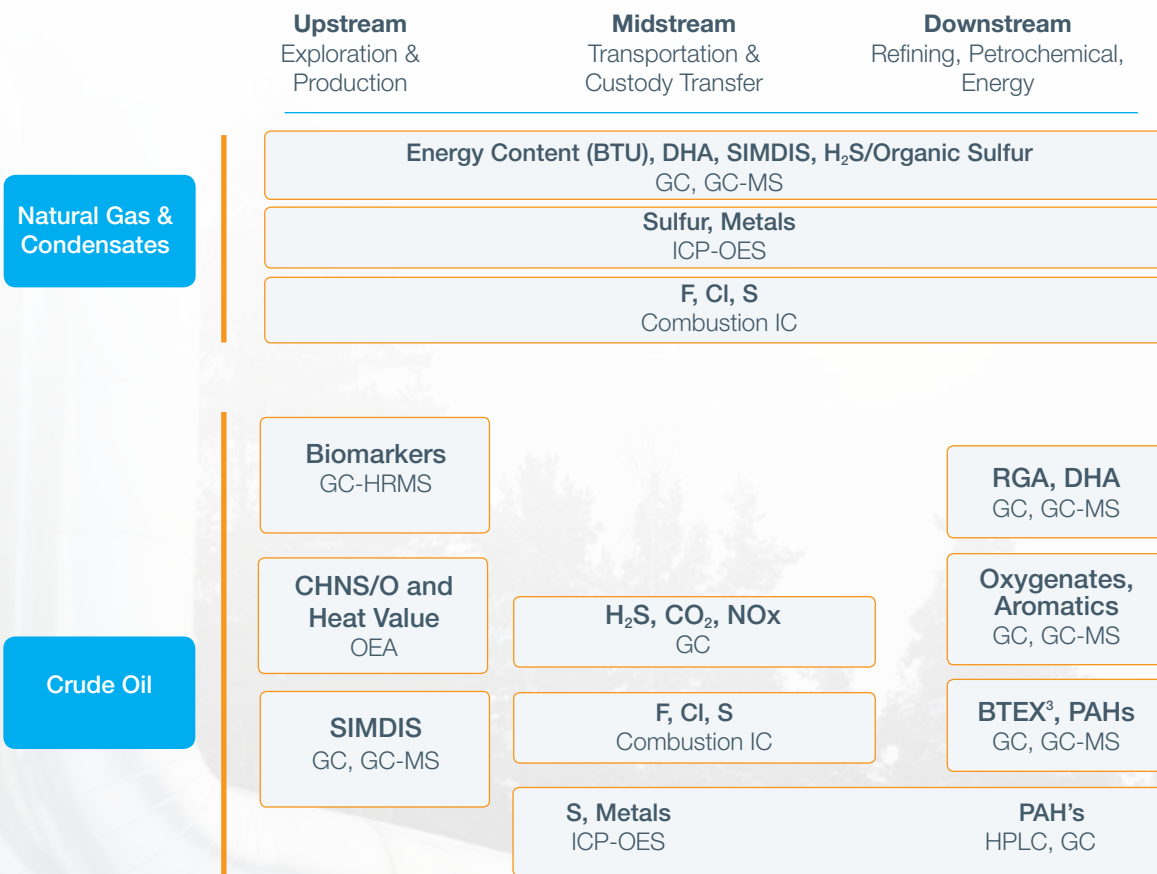


# Petroleum and Natural Gas Workflows

You have a broad choice of analytical techniques in petroleum and natural gas workflows based on the process, matrix, application, and analyte of interest.

## Feed Stock Testing

QA

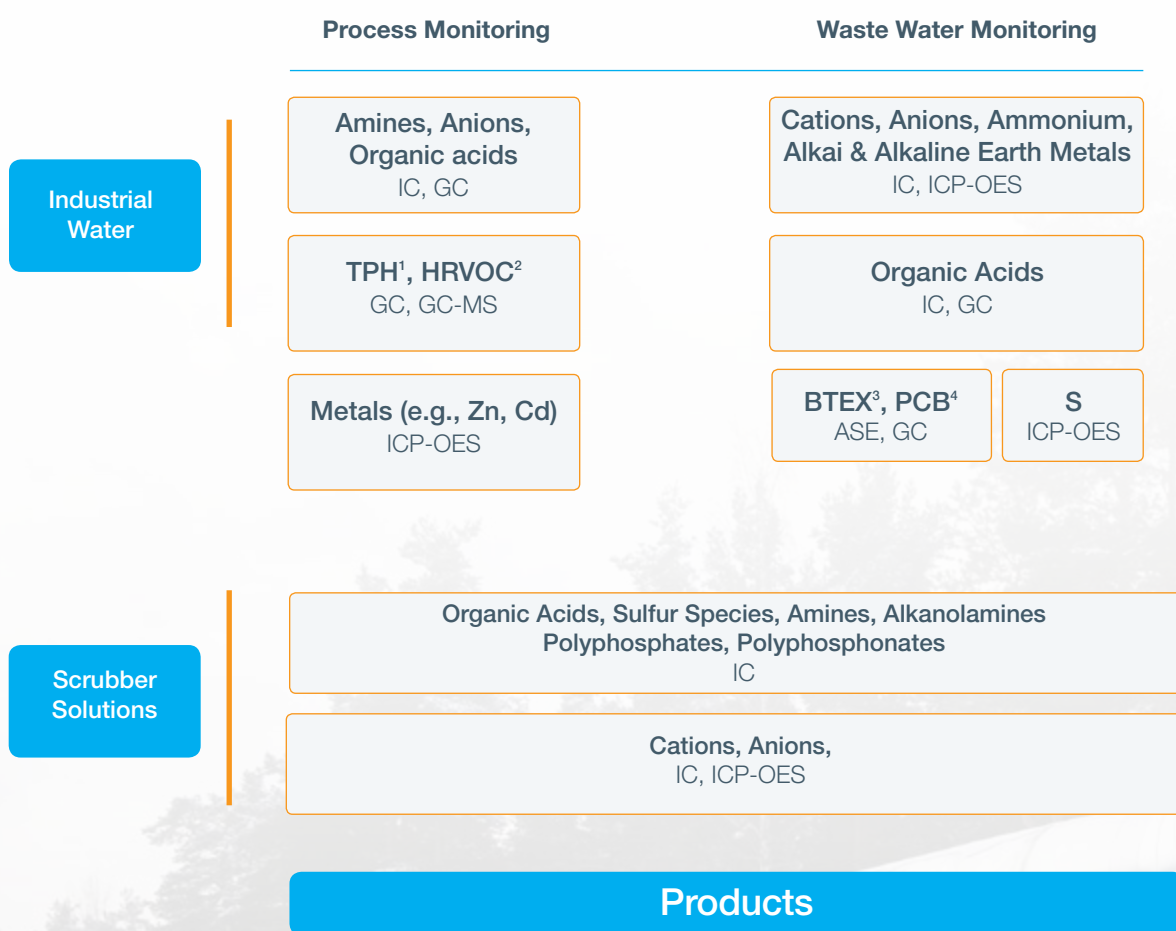


## Products

LIMS leverages all process steps

# Industrial Water Process Workflows

There is also a broad choice of analytical techniques for your industrial water process workflows based on the process, matrix, application, and analyte of interest.



LIMS leverages all process steps

1. Total petroleum hydrocarbons
2. Reactive volatile organic compounds
3. Benzene, toluene, ethyl benzene, xylenes
4. Polychlorinatedbiphenyl

# System Solutions

Analytical instrumentation for the successful exploration, transport, and production of traditional and new forms of fossil fuels.

## Elemental Analyzer

The Thermo Scientific™ Flash 2000 is an organic elemental analyzer (OEA) that enables automated characterization of oil, lubricants, and petrochemical products by the determination of nitrogen, carbon, hydrogen, sulfur, and oxygen.



## GC & GC-MS Analyzers

### Natural Gas Analyzers

Whether you analyze for BTU, BTEX, sulfur, or a combination of these, we offer over 20 different configurations of analyzers that are tested and ready to run GPA, ASTM, IP, and UOP methods.

### Hydrocarbon Processing Analyzers

Our full suite of analyzers are built and tested to meet the latest industry standards for all stages in the refining process from incoming crude or condensate characterization to final product specification.



## High Resolution GC-MS

Upcoming challenges for the oil and gas industry will require improved levels of productivity. The Thermo Scientific™ Q Exactive™ GC-MS/MS is the industry's first instrument to integrate high-resolution GC and high-resolution accurate-mass (HRAM) Thermo Scientific™ Orbitrap™ Mass Spectrometer (MS).



## Ion Chromatography

Ion chromatography (IC) is a necessity for key analytes in the processing and refining of fossil fuels. Thermo Scientific™ Dionex™ Integriion™ high pressure IC (HPIC™) systems enable maximum instrument uptime with automated consumables tracking\* and innovative ease-of-use features.



## Combustion Ion Chromatography

Combustion ion chromatography (CIC) combines an automated quick furnace with IC to determine individual halides and sulfur (as sulfate) in solids, liquids, gases, and liquefied petroleum gases (LPGs).



## Inductively Coupled Plasma–Optical Emission Spectroscopy

The Thermo Scientific™ iCAP™ 7000 Plus Series Inductively-coupled Plasma Optical Emission Spectrometer (ICP-OES) offers fast start-up, simple maintenance, and a small footprint. It can analyze high-salt matrices as well as complex organic samples like crude oil for inorganic species that could cause damage downstream.



## Laboratory Information Management Systems

Incorporate a fully integrated laboratory platform encompassing laboratory information management, scientific data management, and lab execution to ensure your process runs smoothly using Thermo Scientific™ SampleManager LIMS™.



## Chromatography Data System Software

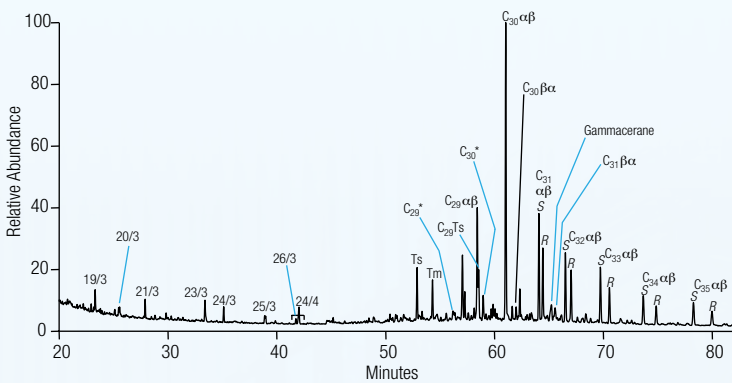
Utilize the Thermo Scientific™ Dionex™ Chromeleon™ Chromatography Data System software for instrument control, data viewing, data processing, and reporting to streamline your process. This is the first CDS to combine separation and mass spectrometry in an enterprise environment.



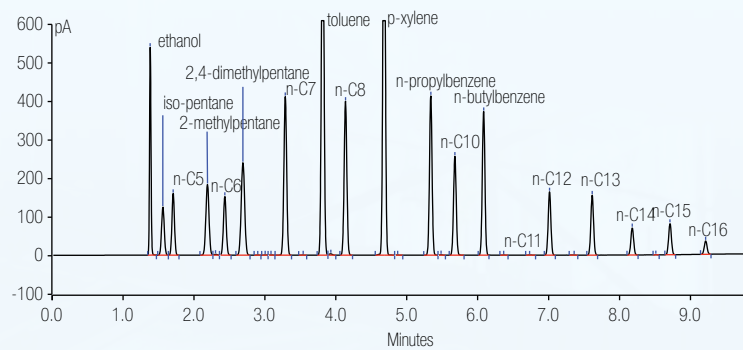
\* The wireless transmitter devices may not be authorized as required by the laws of your country; and these features will not be offered for sale or lease, or sold or leased, until proper authorization is obtained. Please consult your local sales representative for details.

# Upstream Sector

The upstream oil and gas sector encompasses both exploration and production of the fuels. Specifically, it includes searching for potential underground or underwater crude oil and natural gas fields, exploratory drilling, and established drill operations that bring the natural gas and crude oil to the surface.



**Figure 1.** The distribution of terpanes (biomarkers used in estimating the economics of crude by analyzing the oil-source rock as an indicator of source, maturity, migration, and biodegradation) in the aliphatic hydrocarbon fraction of crude oil samples. Analysis was performed using a Thermo Scientific™ DFS™ high resolution GC-MS (or equivalent Q Exactive GC Orbitrap GC-MS/MS) equipped with a multiple ion detector.



**Figure 2.** Determination of the boiling point range of gasoline with ethanol by ASTM D7096 simulated distillation. Samples were analyzed using a TRACE 1300 Series GC.

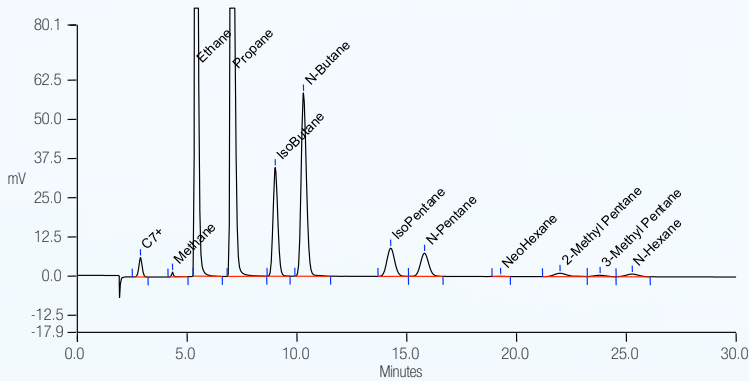




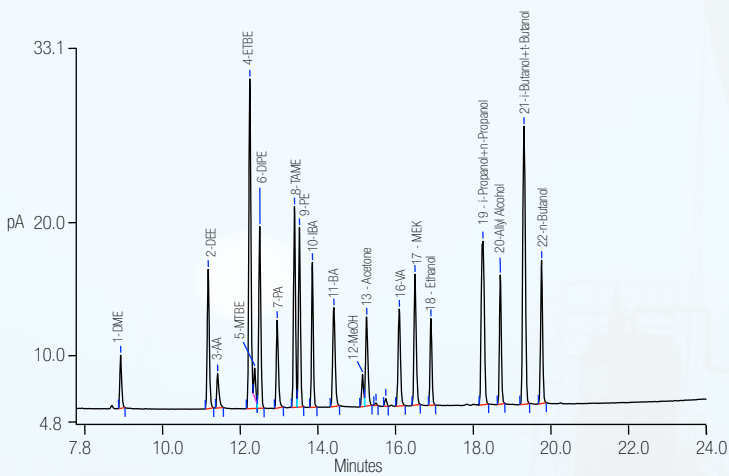
# Midstream Sector

The midstream oil and gas sector refers to the transportation, storage, and wholesale marketing of natural gas, crude, or refined petroleum products. Pipelines, rail cars, and ships are used to move crude oil and natural gas from production sites to refineries and deliver the various refined products to downstream distributors.

Any time natural gas changes hands - from initial release at the drill site until it reaches the end user - it is tested twice, by both the seller and buyer. The test results are compared as a critical quality control step in the process.



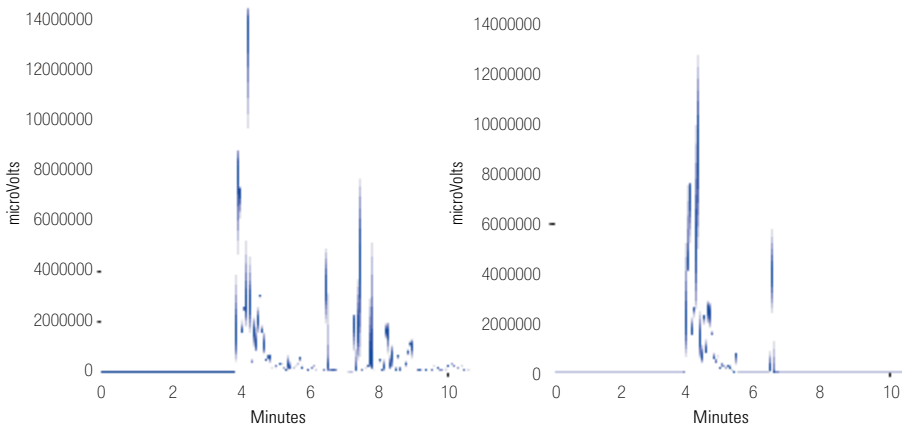
**Figure 3.** Determination of the calorific value of natural gas liquids (NGLs) by a TRACE 1300 Series GC with a thermal conductivity detector by GPA Method 2177.



**Figure 4.** Analysis of corrosive oxygenates in LPGs and other light hydrocarbons samples by a TRACE 1310 Series GC by ASTM D7423.

# Downstream Sector

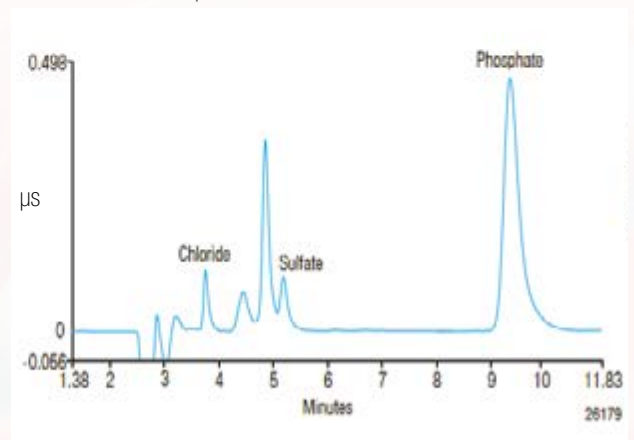
The downstream oil and gas sector covers the refining of petroleum crude oil, the processing and purifying of raw natural gas, and distribution of petroleum or gas. Products are divided into light distillates (LPG C3-C4), gasoline (C3-C12, naphtha C6-14), middle distillates (kerosene, diesel C9-C16, jet fuel C9-C17) and heavy distillates (lubricating oil C20+).



**Figure 5.** Analysis of aromatics (used to boost octane levels in gasoline) is shown without backflush (left) and with backflush (right). In the right chromatogram the heavier matrix components are eliminated, leaving the column and detector cleaner. Analysis was performed using a TRACE 1310 Series GC with FID detector and Thermo Scientific™ TraceGOLD™ GC capillary column.

	Naphtha spike at 2.4mg/kg	RSD on three replicates of the spike	Instrument Detection Limit
	mg/kg	%	µg/kg
Ag 338.389 nm	2.39	0.558	0.8
Al 308.215 nm	2.37	0.188	2.6
As 189.042 nm	2.44	0.302	15
B 208.595 nm	2.17	1.207	14
Ba 223.527 nm	2.35	0.637	1.3
Cu 184.006 nm	2.35	1.426	8.1
Cd 214.438 nm	2.38	0.970	1
Cr 267.716 nm	2.37	0.248	0.8
Cu 324.754 nm	2.41	0.207	0.4
Fe 238.204 nm	2.39	0.548	1.8
Mg 279.553 nm	2.40	0.087	0.08
Mn 293.930 nm	2.38	0.227	0.8
Mn 281.615 nm	2.38	0.233	2.2
Na 589.592 nm	2.41	0.546	13
Ni 231.604 nm	2.37	0.751	5.0
P 178.264 nm	2.40	0.442	15
Pb 220.353 nm	2.35	0.391	16
Si 212.412 nm	2.40	0.467	10.5
Sr 283.999 nm	2.37	0.456	20
Ti 334.941 nm	2.37	0.153	0.4
V 309.311 nm	2.37	0.387	0.9
Zn 213.856 nm	2.39	0.235	0.8

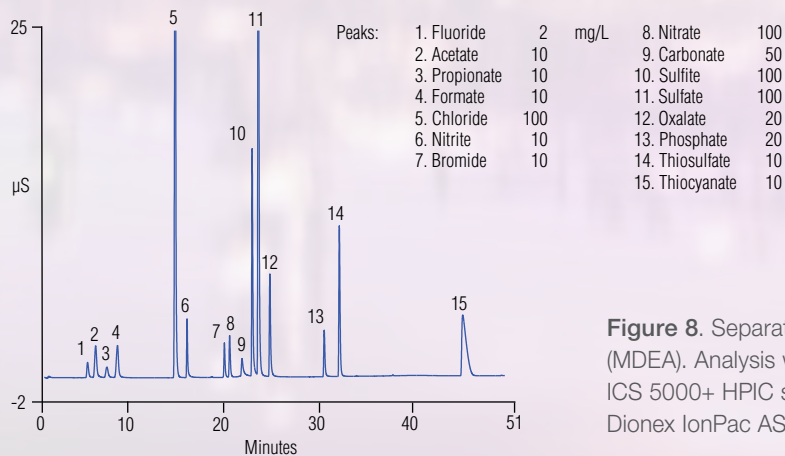
**Figure 6.** Analysis of trace elements in naphtha. Results for the spiked naphtha with relative standard deviation % (RSD %) of the three replicate measurements are within acceptable limits.



**Figure 7.** The separation of corrosive chlorine and sulfur in petroleum samples by CIC using a Thermo Scientific™ Dionex™ IonPac™ AS15 anion exchange column with suppressed conductivity detection.

# Industrial Water Processes

Industrial water processes keep the refinery operational. They include the use, treatment, and analysis of scrubber solutions, boiler/cooling water, and waste water. Scrubber solutions include aqueous alkanolamine solutions used to neutralize acidic gases (e.g., carbon dioxide and hydrogen sulfide) and remove them from the process stream to prevent equipment corrosion or release into the atmosphere. Similarly, boiler/cooling water is treated with amines to neutralize any acidic buildup. Waste water analysis tests for analytes such as polyphosphate scale inhibitors and trace anions such as organic acids in condensate discharge water.



**Figure 8.** Separation of heat stable salts in 30% methyldiethanolamine (MDEA). Analysis was performed on a Thermo Scientific™ Dionex™ ICS 5000+ HPIC system with suppressed conductivity detection using a Dionex IonPac AS11-HC column and KOH gradient.



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