

THE PROFESSIONAL MECHANICAL ENGINEER IN THE OIL, GAS AND CHEMICAL INDUSTRY

Institution of
**MECHANICAL
ENGINEERS**

Severn Trent Biomethane Plant at Roundhill
installed by CNG Services Ltd

Improving the world through engineering

CONTENTS

Introduction	3
Oil, gas and chemical industry in the UK	4
Divisions and sectors	5
Mechanical engineering roles in the oil, gas and chemical industry	7
Acquiring the skills	9
Information sources	10
Market trends	12
Relevant legislation	13
Professional development	14

INTRODUCTION

This booklet has been prepared to identify the information, training, and skill sets necessary to pursue a career in the Oil, Gas and Chemical industry as a mechanical engineer. It is hoped that the information contained will be of value to apprentices, students and graduate engineers and that it will encourage the consideration of a career as a mechanical engineer in the Oil, Gas and Chemical industry. Guidance on and direction to other sources of information is included.

Engineering in the oil, gas and chemical industry

Engineering in the Oil, Gas and Chemical industry is challenging because the materials handled are often hazardous and, therefore, the plants processing them come under considerable scrutiny both by the regulatory authorities and by the public. It is this high profile that makes engineering in this sector exciting with tasks ranging from process containment to the moving of products and intermediates. Typical challenging demands for mechanical engineers today include reducing cost, operating aged assets, reducing energy consumption, complying with stricter environmental regulations and reducing carbon emissions.

The safe and sustainable operation of process plants requires significant input from mechanical engineers specialising in the

design, development, research, operation and maintenance of process equipment. So by becoming an Engineer in the Oil, Gas and Chemical industry one can fulfil a vital role in society.

Within the Oil, Gas and Chemical industry mechanical engineers with their broad range of technical training are often found in multi-disciplined roles within the asset management and project teams. Many mechanical engineers diversify and acquire knowledge and experience, constantly learning and adding to their expertise. The international nature of the industry, which is supported by many global companies, means that there are many opportunities for mechanical engineers to travel all over the world.

OIL, GAS AND CHEMICAL INDUSTRY IN THE UK

Oil and gas

The oil and gas sector is facing a period of significant change and innovation as the world reacts to the threat of climate change and looks to cleaner energy sources such as hydrogen.

Oil and gas for the UK has traditionally been produced offshore in the North Sea, but this production is declining. In 2018, it supplied the equivalent of 45% of UK energy needs and 59% of UK's oil and gas demand. It is primarily used for transport, heating and electricity generation.

Data source: Oil and Gas UK Economic Report 2019

The industry also produces many other petrochemical products. Examples of these are petrol, diesel, liquid petroleum gas (LPG), jet fuel, gas oil, heating oil and bitumen as well as feedstocks for lubricants.

Transformation has already started in the sector to meet the ambition of a net-zero UK economy by 2050. This is leading to exciting opportunities for engineers who want to have an impact on energy futures, and for those who enjoy tackling a tough challenge.

Chemicals

The chemical industry in the UK is one of the longest-established in the world and including pharmaceutical production is UK's largest manufacturing exporting sector with exports of £56bn in 2018/2019. This accounted for over 15% of all UK manufacturing exports. It directly employs around 150,000 highly skilled people nationwide. If indirect and supply chain employees are added the total is around half a million.

Data source: Chemical Industries Association and Office for National Statistics: UK trade

Products of the chemical industry are the basis for almost every manufacturing activity. They are to be found in the making of paints, medicines, fertilisers, pesticides, herbicides, animal health products, water treatment materials, colouring agents, man-made fabrics, detergents, disinfectants, polishes and cleansers, cosmetics and toiletries.

DIVISIONS AND SECTORS

Oil and natural gas

Oil and natural gas is split into two principal segments. That which is responsible for exploration and extraction of reserves is known as the “upstream” segment and that responsible for the splitting of oil into its fractions and clean-up is known as “downstream” processing. This booklet focuses on mechanical engineering in “downstream” processing.

Chemicals

The chemical industry is split into two principal sectors: chemical processing and industrial gases.

Chemical Processing

Chemical processing takes feedstock from both the oil and gas and industrial gas sectors as well as natural resources such as salt.

Major segments of chemical processing include:

- **Petrochemicals, Industrial Organic Chemical Producers**
Producers of olefins, alcohols, ethylene and ethylene-based chemicals such as ethylene oxide/ethylene glycol, propylene, methanol and related products.
- **Industrial Inorganic Chemicals (Specialty Chemicals)**
Major companies engaged in the production of acids, compounds (sodium, phosphate, etc), activated carbon, chemical catalyst, peroxides, and similar chemicals.
- **Agricultural Chemical Industry**
Bulk liquid and solid (granular, powder) agricultural product producers, including fertilizers, herbicides, pesticides, fungicides, and intermediates, such as urea, ammonia, nitric acid, and ammonium nitrate.
- **Plastics, Rubbers, and Resins Manufacturers**
The manufacturing of synthetic resins, plastic materials (polyethylene, polypropylene and similar commodities), non-vulcanizable elastomers, synthetic rubber by polymerization or copolymerization.
- **Fibres**
Manufacturers of manmade non-cellulosic fibres such as fluorocarbon fibres, elastomeric fibres, acrylonitrile fibres, nylon fibres, polyester fibres, and similar commodities.

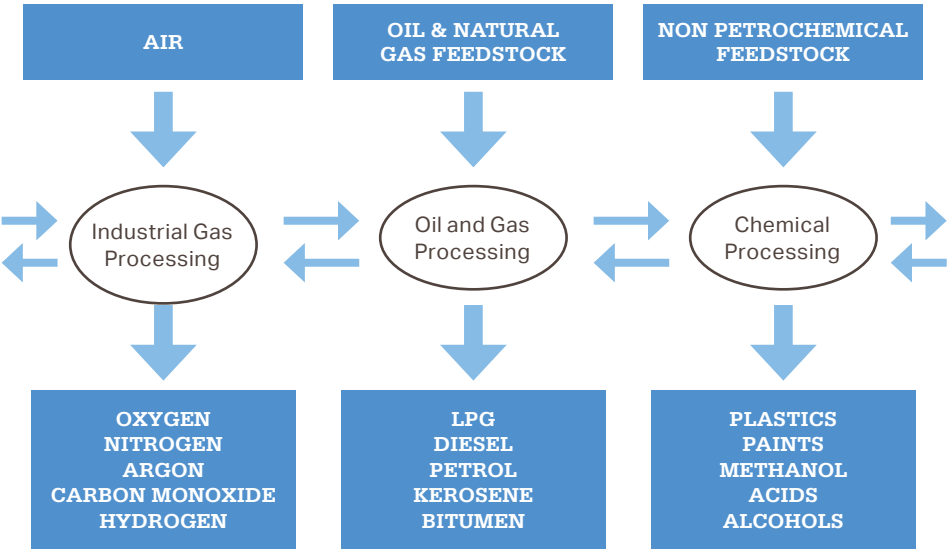
• **Producers of Other Chemicals**

Producers for a variety of chemicals including explosives, surfactants, inks, dyes, detergents, glues, lubricants, paints and coatings, solvents, fire retardants, and chemical preparations, and the compounding of purchased plastics.

Industrial Gases

Industrial gas plants use air as their principal feedstock to produce oxygen, nitrogen, argon and rare gases both to industry end users and to oil refineries and petrochemical plants for further processing. Other products require feedstock from the oil and natural

gas sector e.g. natural gas which is reformed to produce hydrogen and carbon monoxide to provide feedstocks to the chemical processing industry. This cross supply of products between the industry sectors is illustrated in the figure below.



At the heart of the processes used by the industry lies the transportation of fluids requiring static and dynamic fluid handling equipment, pressure vessels to accommodate and contain

chemical processes, piping systems between process elements and product storage facilities all of which require the design services of mechanical engineers.

MECHANICAL ENGINEERING ROLES IN THE OIL, GAS AND CHEMICAL INDUSTRY

Mechanical Engineers through their education and training develop a wide range of skill sets which allow them to diversify into a wide range of roles. The principal areas in which they are employed are:

- Plant and equipment design
- Plant operation, maintenance and reliability
- Plant integrity assurance
- Construction management
- Energy innovation, research and development

Few operating companies with the exception of the industrial gas companies now employ in-house engineering groups. The engineering of new plant and plant revisions are usually outsourced to engineering contractors. The mechanical engineers employed by operating companies therefore tend to be focussed on plant maintenance and the management and supervision of contractors both for design and construction and for maintenance.

Engineering Procurement and Construction (EPC) contractor roles for mechanical engineers include:

Design and technology engineers

Responsible for:

- Rotating machinery including pumps, compressors and turbines
- Process units, assemblies and specialist equipment items
- Fired equipment including reformers, flares, fired heaters
- Pressure vessels, storage tanks and heat exchangers
- Piping systems including layout and piping specification
- Noise, insulation, coatings, materials, and other mechanical design issues

Project Engineers

Responsible to the project manager for coordinating the engineering aspects of a project from conceptual development, design, procurement and construction through to final commissioning. Particular skills include interpretation of drawings, understanding of design standards, scheduling, planning, supervision of engineering staff and site contractors.

Operating company roles for mechanical engineers include:

Conceptual design is very much a creative process where options are explored, technology options are investigated whereas detail design involves engineering analysis, strength of materials, corrosion knowledge etc.

Project Managers

Responsible for managing projects from conception through to handover to the customer. Particular skills include client management, cost management, overall scheduling and project planning, procurement and contract services.

Plant Engineer or Asset Engineer

Responsible for managing site maintenance for both the process plant and the utility plants which may include effluent plants. Duties involve the preparation of equipment efficiency data, management of environmental issues, supervision of maintenance teams, development of work scopes, schedules and planning and managing site contractors.

The UK has a large number of older process plants many in the high hazard sector. The ongoing safe operation and rejuvenation of these process plants requires significant input from Mechanical Asset Engineers.

Pressure Systems Integrity Assurance is a specialism within Plant Engineering involving fitness for service assessments, knowledge of metallurgical degradation, fatigue and strength calculations.

Process plants are complex and their design requires co-ordination between different engineering disciplines within the engineering team. Mechanical engineers will therefore find that they need to work closely with:

- Chemical engineers
- Control and Instrumentation engineers
- Electrical engineers
- Civil engineers
- Structural engineers
- Construction engineers
- Commissioning engineers
- Metallurgists
- Acoustic engineers

The collaborative nature of Plant Engineering provides Mechanical Engineers in their early career with significant exposure to a wider range of technical and business management skills, as such Mechanical Engineers in the Process Industries become well skilled in team leadership and management and often move on to middle and senior management in the Industry.

ACQUIRING THE SKILLS

To become a professional mechanical engineer you will need the building blocks. It all starts at school when you acquire the basic skill sets and knowledge pursuing subjects which might include mathematics, physics, chemistry, science, information and communication technology and computer skills.

Speak to a course advisor at your chosen university to understand more about the topics covered on any particular course, and the eventual career options open to you.

Look out for degree courses that have been accredited by the Institution of Mechanical Engineers or another professional body. These have been independently verified as equipping graduates with the knowledge and understanding required by the profession.

All IMechE Engineering courses are listed on the Engineering Council's website:

www.engc.org.uk/education-skills/course-search/acad/



@ Barrie Gillam

INFORMATION SOURCES

IMechE Library

The IMechE Library offers a wealth of information, on all aspects of engineering. Members can access over 40,000 online titles from leading engineering publishers, wherever they are based.

The IMechE Library team offer a free enquiry service supplying literature reviews, company data or materials

properties information, send enquiries to library@imeche.org

Books and standards are also available via free postal loan from the library at IMechE Headquarters.

Useful web links

- **British Chemical Engineering Contractors Association**
Trade association for UK companies that provide engineering, procurement, construction and project management services to the process industries
www.bceca.org.uk
- **BSI Oil, Gas & Energy Content Hub**
BSOL offers standards for the extraction, refining and distribution of oil and gas
www.bsigroup.com/en-GB/standards/british-standards-online-database/content-hub/content-hub-oil-gas-energy/
- **Chemical Industries Association**
UK trade association for chemical and pharmaceutical companies
www.cia.org.uk

- **Energy Institute**
International (UK based) professional body for energy industries
www.energyinst.org
- **Energy Systems Catapult**
Independent analyses and reports on the transformation of the UK's energy sector to meet carbon reduction targets
es.catapult.org.uk/reports/innovating-to-net-zero
- **Health and Safety Executive Offshore**
HSE's Offshore Division (OSD) is responsible for health and safety in the UK offshore oil and gas industry
www.hse.gov.uk/offshore



- **Institution of Chemical Engineers**
www.icheme.org/knowledge
- **Institution of Gas Engineers & Managers**
 IGEN provide gas standards that cover safety regulations, knowledge, best practice and gas engineering requirements.
www.igem.org.uk/technical-services/technical-gas-standards
- **Oil and Gas UK**
 Trade association for the UK offshore oil and gas industry and a source of upstream oil industry reference.
www.oilandgasuk.co.uk
- **United Kingdom Onshore Oil and Gas (UKOOG)**
 Trade association representing UK onshore oil and gas exploration and production companies
www.ukoog.org.uk
- **United Kingdom Petroleum Industry Association**
 UK trade association for oil refining and marketing companies
www.ukpia.com

MARKET TRENDS

Currently, and in the short and medium term, there is significant scope for engineering development in the following areas of interest in the oil, gas and chemicals industries:

- Plant de-commissioning and re-use
- Plant and process energy efficiency improvement
- Plant and process environmental impact and emissions reduction
- Energy generation and conversion processes and schemes (energy from waste, hydrogen schemes, energy storage systems, carbon capture, low carbon fuels, recycling, etc.)
- Potential sea level rise and global warming

Examples of major oil, gas and chemical companies include:

Operators

Essar Oil UK
Phillips 66
Ineos
Petrolneos
BP
Total
Valero
ExxonMobil
Air Products
BOC
Dow
Sabic
Lotte Chemicals
DuPont
Huntsman
LyondellBasell
ConocoPhillips
CF Fertilizers
Perenco
Bayer
Centrica
Chemoxy International
Thomas Swan and Co
Inter Terminals
Greenenergy

Contractors

Jacobs
Costain
Fluor
KBR
McDermott
TechnipFMC
Wood
Cameron
Petrofac
SNC Lavalin Atkins
Mott MacDonald
Bechtel

Equipment Manufacturers in the UK

SPP Pumps
Hayward Tyler
GE Oil and Gas
Emerson
SPX Flow
Sundyne
Amarinth
Atlas Copco
John Crane
AESSeal
Flowserve
Brook Crompton

RELEVANT LEGISLATION

Engineers working in the oil, gas and chemicals industries must be aware of, and ensure that their work conforms to, a wide range of legislation and regulation. These include national as well as regional and international laws and, as well as influencing many specifically technical aspects of a design or scheme, they also set out rules which will indirectly affect it, such as: the need to obtain development permits and consents, environmental protection considerations; health and safety requirements; restrictions on how a project can be financed and commercial activities will be taxed and/or subsidised; and, how goods and services may be procured and transported from jurisdiction to jurisdiction. Understanding this body of legislation is vital, and can be a fascinating, part of an engineer's role. The following list is intended to give an initial overview of the breadth of laws that an engineer working in the UK may need to consider.

- Pressure Equipment, System Safety regulations and associated legislation
- Pipelines Acts
- Construction Design and Management Regulations
- Control of Major Accident Hazards Legislation (COMAH)
- Control of Substances Hazardous to Health Regulations (COSHH)
- European Emissions Trading Scheme Directive and associated legislation
- European Integrated Pollution Prevention and Control Directive
- European Industrial Emissions Directive
- International Convention for the Safety of Life at Sea (SOLAS)
- Convention for the Prevention of Pollution from Ships (MARPOL)
- International waste-disposal and dumping conventions (OSPAR and London Conventions)
- Health and Safety at Work Act and associated regulations and guidance
- Town and Country Planning Act and subsequent Planning Acts
- Treaties of the European Union – setting out, amongst many other things, restrictions on state funding for projects
- Energy Acts
- Tax Acts
- Public Procurement Laws
- Competition Acts
- The Climate Change Act 2008 and 2050 Target Amendment

PROFESSIONAL DEVELOPMENT

Training and development for professional registration

Training and professional development builds upon academic skills and can enable developing engineers to work to and achieve registration as a Chartered Engineer (CEng) or Incorporated Engineer (IEng).

For details visit: www.imeche.org/careers-education/careers-information/what-is-mechanical-engineering/academic-routes-into-mechanical-engineering

Mentoring

It is always useful to work with a mentor towards CEng/IEng. If you are working for a company with an accredited Monitored Professional Development Scheme (MPDS), an MPDS mentor will be allocated to you by your company. If you are not on an official scheme, you may work with any engineer who has experience of professional registration and ECUK Spec.

The IMechE provides guidance, support and tools to help record your competences and evidence. For details visit www.imeche.org/membership-registration/professional-development-and-cpd/career-developer

Becoming a member

As an apprentice, student or experienced engineer, IMechE has a membership type appropriate to your career stage. For details visit: www.imeche.org/membership-registration/become-a-member

Training and Professional Development for your career

The Institution of Mechanical Engineers offers training and professional development short courses from a range of expert providers, enabling outstanding professional development opportunities for all engineers, technical professionals and scientists at all stages of their careers. View web page www.imeche.org/careers-education/careers-information/whatis-mechanical-engineering/academic-routesinto-mechanical-engineering



Please contact us with any comments, suggestions
or questions at **ge@imeche.org**

For information on Oil and Gas related events go to
www.imeche.org/events

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