ESDU

Engineering for Academia

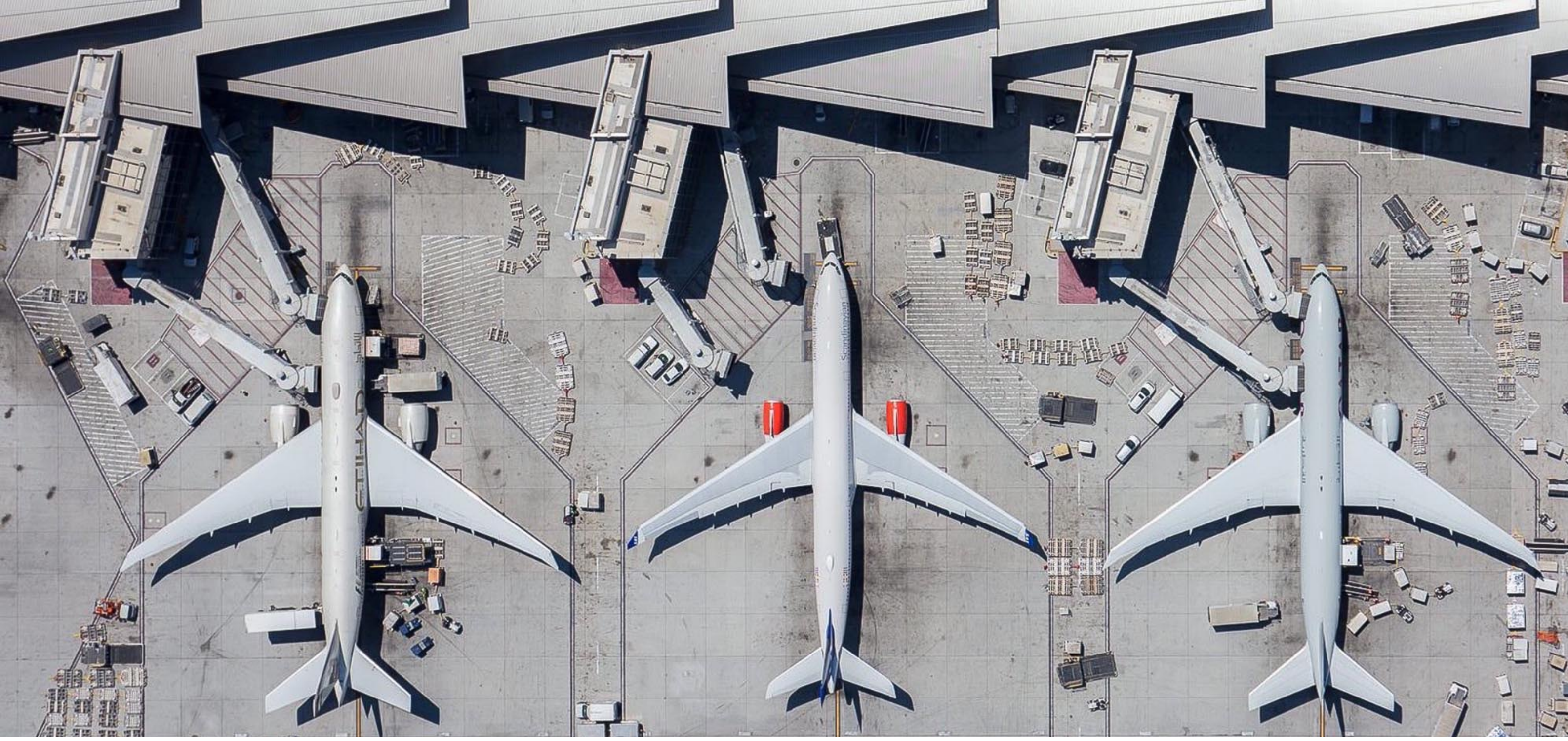
How can you benefit from ESDU?

- ESDU is widely used by international aerospace companies and other engineering industries. It is considered to be the most accurate, up-to-date and comprehensive collection of validated data and methods. Every Boeing and Airbus aircraft has numerous Best Practice Design Guides incorporated within their designs.
- Each series is produced and validated by committees of experts drawn from a broad range of academic, research and industry backgrounds.
- Information is presented in a clear and concise format and is the result of careful distillation of large information sources. There is a strong emphasis on the use of unpublished information taken from sources only available to ESDU - a direct result of key communication links between academia and industry.

The ESDU Committee Structure

The ESDU committee structure consists of over 250 members from distinguished organizations:

- Airbus
- Boeing
- SAAB
- Lockheed Martin
- Bombardier
- Gulfstream
- Cranfield University
- University of Cambridge
- Imperial College
- University of Oxford
- Aircraft Research Association
- The University of Tokyo, Japan



Engineering Departments

ESDU data can be used by faculty heads within their teaching methods and curriculum. The unique advantage of this source of material is the ability to make the students consider the systems design aspects that will encompass, including materials, fluid flows, pressure, fatigue and vibration. It encourages them to think laterally and emulate practical every day engineering tasks.

AEROSPACE/AERONAUTICAL ENGINEERING

Aerodynamics, Performance, Fluid-Flow, Dynamics and control, Propulsion, Fatigue and Fracture Analysis, Vibration and Acoustics.

MANUFACTURING ENGINEERING/ METALLURGY

Mechanical Properties, Microstructure, Structures, and Bonding Deformation of Materials, Composites and Material Selection

MECHANICAL ENGINEERING

Fluid dynamics, Mechanisms, Tribology, Statistics, Thermodynamics, Vibration, Fatigue, Structures and Materials.

CIVIL/STRUCTURAL ENGINEERING

Structural Engineering and Fluid Mechanics.

ESDU Academic Package

The ESDU Academic Package provides data and software tools that address the full range of design methods, including:

AERODYNAMICS

Aerodynamics contains a wide and ever-increasing range of data and methods applicable to the project design of aircraft, guided weapons, space rockets, and more. The data covers general aero-dynamics properties, including atmospheric conditions; airframe components, the effect of power plant/airframe interactions for propeller-powered and jet aircraft; the effect of surface imperfec-tions on drag; the aerodynamics of controls, flaps and leading-edge devices; aircraft stability, the aerodynamics of internal flow systems, and more.

AIRCRAFT NOISE

Aircraft Noise concerns itself with the noise pollution in many environments. It is necessary to have reliable methods for the prediction of sound levels generated by various sources, and an understan-ding of the control and suppression of noise. The ESDU Aircraft Noise provides validated data aimed primarily at the aerospace industry but many data items (for example, those on noise barriers and sound propagation) have much wider application and use:

• Industrial and traffic noise problems and health and safety issues faced by industrial hygienists, civil engineers, city planners and architects.

• Anyone interested in predicting, estimating, and analyzing aircraft propulsion, traffic, and industrial noise or in predicting the attenuation of sound as it propagates.

• The estimation of noise from specific sources such as jet exhausts, turbofans, propellers, and air-frames.

COMPOSITES

A rapidly growing collection of data for use in the design of fibre-reinforced laminated composite materials. The information is provided primarily for use in aerospace, but has wide application to other areas of engineering where composite materials offer benefits.

The Sections contain the solutions to many strength analysis problems met in the design of fibre-reinforced laminated composite structures. These include failure criteria, plate vibration and buckling, analysis of bonded joints, and stress concentrations, in addition to the calculation of basic stiffnesses and stresses including built-in thermal stresses.

Laminated composites can be specified in very many forms and assembled in a multitude of lay-up arrangements. Because of this complexity the only practical form in which many of the solutions can be provided is as a computer program, and Fortran programs are provided for many of the analysis methods. In addition to the freedom to change the overall geometry the designer in composites has the freedom to arrange the material strength and/or stiffness to meet the local loading. This complicates the design process and it is often difficult to select a route to the best combination of geometry and material. The Sections contain guidance on the factors influencing the design and suggest methods of achieving the desired solution.

DYNAMICS

Dynamics is a treatment of the behaviour and motion of a system and the resulting stability and controllability of that system, particularly under non-steady conditions where the dynamic nature of the system plays an important part in determining its behavior.

Part of the series is devoted solely to aircraft topics which include the equations of motion, conversion formulae for rotation and translation of body axes, geometric and kinematic relationships for various axis systems, direction and incidence angles and measures of damping.

FATIGUE - ENDURANCE DATA/FRACTURE

Fatigue is concerned with methods and data given for strength calculations on aircraft and aerospace structures as well as general engineering. The data are principally for use when the design philosophy is one of «safe-life design», that is, the structure or component is required to be crack-free for the specified design life.

The major part of the data consists of constant amplitude stress-endurance curves (S-N curves) for aircraft materials (aluminium and titanium alloys and steels) and structural joints (riveted, bolted or bonded).

FLUID MECHANICES, INTERNAL FLOW

Fluid Mechanics, Internal Flow is primarily concerned with flow and pressure losses in pipe or duct networks, losses in components such as ends, valves, orifices, and tube banks, and noise in ventilating systems. The data and methods determine accurate pressure losses in internal flow systems; predicting the performance of apparatus such as heat exchangers, fuel lines and engines; selecting/ testing proper equipment such as pumps and fans. The data is also important for safety reasons, such as in sizing safety.

The data is applicable and relevant to accurate pressure losses in internal flow systems such as:

- Short and medium length pipes for aircraft engines, fuel lines, heat exchangers, and performance critical systems
- Long pipes in oil lines, water supply, and high friction loss systems where economic pump sizing is critical and poor estimates equal high uncertainties and ultimately expensive pumps

Pressure loss data is essential in estimating energy requirements needed to move fluids (gases and liquids) through duct or pipe systems such as process plant networks. When calculating heat transfer, the data helps ensure that the expected mass flow rate is achieved so that specified rates of heat transfer can be obtained.

HEAT TRANSFER

The high cost of energy makes efficient and safe heat transfer processes necessary. For process engineering (fluid processing, pharmaceuticals, petroleum products, steam generation, etc.) the data applies primarily to the performance estimation and design of heat exchangers. It is also relevant in the calculation of heat losses from other equipment. In aerospace, the data helps in the design of heating and ventilating systems and in cooling electronic equipment.

The Sections give step-by-step calculation methods and indicate the limits of applicability and the limits of accuracy of empirical correlations.

MECHANISM

Mechanisms covers methods and data for the design and analysis of cams, gears, linkages and Geneva mechanisms, and also includes contact stress estimation. The data and methods are concerned with the motion, forces, and power transmission associated with the design and evaluation of the moving components of a machine. These components must be designed to produce the output motion required of them and operate within constraints of space and machine timing while maintaining satisfactory dynamic performance and operating life.

The Mechanisms Series is applicable and relevant to all industries involved in the design of machinery with moving components such as:

- Machine tools
- Prime movers
- Materials handling

A complete analysis procedure for the design of internal and external Geneva mechanisms is provided, including a derivation of the basic relationships for kinematic and kinetostatic design, estimation of the forces and torques, evaluation of contact stress and calculation of the lubricant film thickness, including identification of the lubrication regime.

AIRCRAFT PERFORMANCE

Aircraft Performance provides data and methods both for the estimation of the performance of a proposed aircraft at every stage of its design, from project stage to operation, and for performance measurement i.e. speeds, accelerations, range/endurance, take-off/landing, climb/descent, and maneuverability.

Performance measurement methods are used to determine the performance characteristics of aircraft to satisfy airworthiness authorities and purchasers and to improve the knowledge of factors affecting performance so that future designs benefit from current experience.

Performance estimation has as its main objective the synthesis of precise operational data, which accords with flight-test results. However, the spectrum of activities comprising performance estimation also ranges from ‘project» and pre-flight specification, design and development to research studies. Such applications may involve the combination of ESDU methods/data with the customer’s own (usually computerized) methods.

PHYSICAL DATA, CHEMICAL ENGINEERING

The Physical Data, Chemical Engineering Series provides the most reliable correlated data available for the physical properties of a wide range of pure compounds, and some mixtures, used in the chemical industry. The data, which are provided as equations and in tabular form, are based on the most reliable experimental data, both reported and unreported.

Within compound groups, data are extrapolated beyond experimental temperature ranges in a consistent and reliable manner. Reliable estimates are provided for properties of compounds within family groups for which experimental data are not available. Uncertainties are stated over the whole temperature range.

The Physical Data, Chemical Engineering Series provides the following properties data.

- Vapour pressure.
- Liquid density.
- Liquid heat capacity and enthalpy.
- Liquid viscosity.
- Liquid and gas thermal conductivity.
- Fire hazard properties.
- Properties of water substance.

Additionally, the thermophysical properties of a number of industrially- important compounds, including modern refrigerants, are provided on the saturation line from the melting point up to the critical temperature, together with those of the ideal gas.

STRESS AND STRENGTH

The strength analysis is treated of components used in general mechanical engineering. The information has been evaluated by engineers to ensure soundly based analysis leading to safe, cost-effective design.

The information is divided into three principal types. Firstly, the design of commonly used components such as struts, beams, shafts, plates, pressure vessels, pipes, fastenings, welds and springs is considered. The data include stiffnesses, static stresses and deflections, buckling loads and fatigue strengths. Design notes and methodology are covered. Secondly, data for certain stress intensity factors and contact stresses are given.

Lastly, data are presented on the fatigue strength of materials, both as constant amplitude stress versus endurance (S-N) curves and in terms of linear elastic fracture mechanics. The fatigue data are for many low and high alloy and stainless steels made to US, UK and European specifications, and the fracture mechanics data include both crack propagation rates, many down to threshold, and fracture toughness values.

All information on stresses, deflections, stiffnesses and buckling loads is applicable to the usual metals used in engineering and to any other isotropic material such as glass, rubber or plastic.

AIRCRAFT STRUCTURES

Aircraft Structures is relevant to Structural components such as wing elements, fuselage sections, rivets, buckling, and other load- bearing components. Virtually all metallic engineering materials
Example: A designer of a panel typically desires data on the behavior of the panel and its stiffeners in addition to information on such details as rivets and the effect on stability and maximum stress around holes and other features.

Buckling can take several forms. The simple strut can bend; twist or a flange can buckle locally. Plates can have several waves along and across them and these can be skewed.
Each form or mode has to be considered by the designer to see which might affect the design. The calculations are often long and involved.

TRANSONIC AERODYNAMICS

Transonic Aerodynamic Series is applicable to:

- 2 D airfoils
- Wings, bodies and cowls for aircraft or missiles

The Sections provide methods of calculating the pressure distribution and loading on aerofoils and wings in high subsonic flow, the drag-rise Mach number and/or the wave drag of aerofoils, wings and bodies, and the exchange rates between pertinent aerofoil and wing design parameters at the drag-rise condition. For aerofoils and wings, particular attention is paid to the prediction of shock-induced separation and both direct (CFD) prediction and semi-empirical methods are given.

TRIBOLOGY

Tribology series provides methods and data for design, analysis and selection of components associated with lubrication and is composed of items on bearings, temperatures, contact stresses, lubrication, seals, and material selection. Tribology often is regarded as the meeting point of all mechanical engineering disciplines and is primarily used in mechanical engineering, but can apply to any industry involved with machine design or evaluation.

Any interaction of moving surfaces of a machine may limit its life or performance through friction, wear and heat. The Tribology Series focuses on this interaction. The use of its unique design data eliminates undue wear, premature failure, and high maintenance costs. Its use reduces manufacturing costs and weight that comes from unnecessarily complex or inappropriate design and assembly. Additionally, its use allows the life expectancy of the machine component to be predicted.

It is necessary to appreciate that many machine components are available ‘off-the-shelf’, but need to be carefully selected by a designer. The designer still needs to assess the performance of such a component in order to know what is needed and whether it performs satisfactorily.

VIBRATION AND ACOUSTIC FATIGUE

Vibration and Acoustic Fatigue series is applicable and relevant to:

- Aircraft (engine, fuselage, wings)
- Heating and Ventilation (pump systems, fan units)
- Nuclear power plants (pipes, storage tanks, cooling systems)
- Shipbuilding. (steel structures)
- Motors

Example: Propeller and jet engines generate strong sound pressure fields. These sound pressure fields are so strong that they will excite the aircraft structure and cause certain parts of it to vibrate at high levels. The excitation of the structure is especially serious during take-off when the engines are working at maximum thrust. Exposure to high vibration levels for a long time will, if the levels are sufficiently high, eventually cause fatigue and the development of cracks and defects in the structure.

WIND ENGINEERING

The Wind Engineering series is relevant to:

- Circular and multi-sides structures, i.e. Stacks, towers, cables, pipelines, antennas
- Plate-like and prismatic structures, i.e. buildings, panels, hoardings, dish aerials
- Lattice Structures i.e. towers, masts, pylons, wind turbines
- Because of the high cost, in terms of damage and danger, of inadequate design against wind effects - and the equally significant cost of over-design - wind engineering data are needed for the design and assessment of all structures exposed to high wind.

MMDH

Much of the information on force and pressure coefficients is also applicable to other fluid flows, such as water. The meteorological data are also of direct relevance in predicting the response of aircraft, missiles and space vehicles to wind gusts in the lower layers of the atmosphere (below about 3000 meters).

ESDU Academia Project Example

The following is an example of an undergraduate project/thesis that can be completed with ESDU:

PRESSURE VESSEL DESIGN PROJECT

Students may design a pressure vessel, containing a specified volume of fluid without leakage for a specified life:

Design a pressure vessel to store ___m³ of oil maintained at a nominally constant operating pressure and temperature of ___N/m² and ___°C, respectively. The operating life of the system is___ years and the pressure vessel is filled and emptied ___times a day.

To develop the design, use ESDU Data Items in the Structures, Fatigue Endurance Data, Fluid Mechanics Internal Flow and Stress and Strength Series. The MMDH series may also be consulted for material properties.

Preliminary Design

Data Items 65002, 66010 and 67017 provide guidance for determining the elastic stresses in cylinders and pressure vessels of various shapes.

Pipe Design

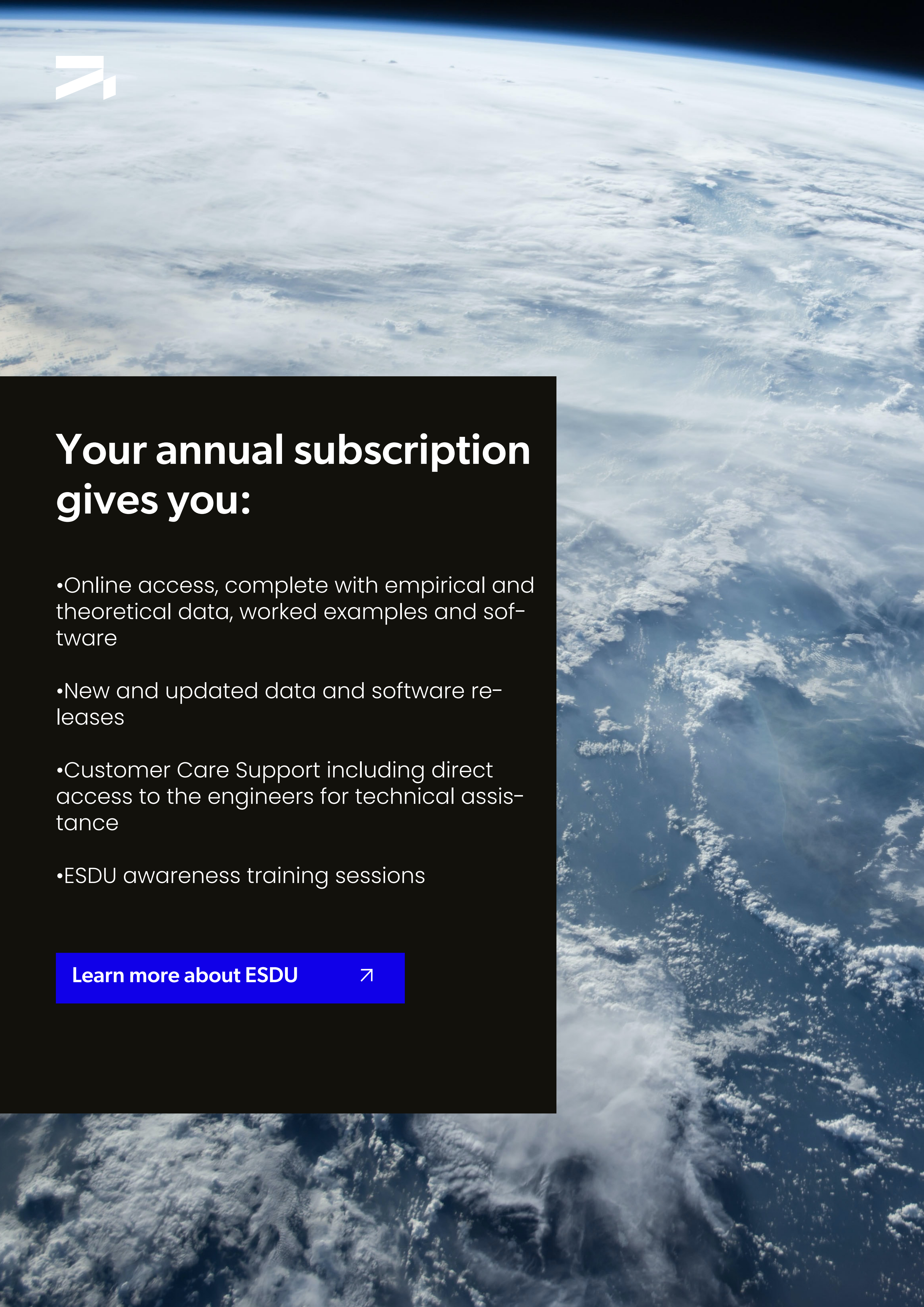
Develop the pressure vessel design to include the inlet and outlet pipes. These pipes must be connected to other parts of the pressurised system by bolted joints to facilitate installation and replacement. Consider ESDU Data Items 74043, 75014 and 81041 to analyse the pipe stresses and Data Items 85021, 86014 and 87023 for the bolted joint. Data Item 64001 is the starting point for assessing the effect of any stress concentrations that may occur in the design.

Assessing the Possibility of Fatigue Failure

Consult the ESDU Fatigue Endurance Data and analyses capable of assessing the potential for fatigue failure of the pressure vessel, its associated piping and bolted joints

Design Development

A modal analysis may also be carried out using the same FEA model to estimate the fundamental natural frequency of the vessel. Refer to ESDU Data Items within the Fluid Mechanics, Internal Flow series for guidance on the significance, or otherwise, of pressure surges in the system.



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