According to Douglas Adams, author of The Hitchhiker’s Guide To The Galaxy, the answer to life, the universe and everything is 42. But a strong case exists, that without stored energy, life as we know it, may not have begun at all. The nuclear furnace at the centre of our solar system, the Earth’s liquid metal core, the polar ice caps, the oceans, seas and rivers, the land masses – all contribute to provide and regulate the finite conditions and sources of stored energy that allows us to exist. The law of Conservation of Energy, also known as the first law of thermodynamics, states that the energy of a closed system must remain constant, it can neither increase nor decrease without interference from outside. The universe itself is a closed system, so the total amount of energy in existence has always been the same. The forms that energy takes, however, are constantly changing.
TYPES OF STORED ENERGY

Potential and kinetic energy are two of the most basic forms. Gravitational potential is the stored energy of a boulder pushed up a hill, poised to roll down. Kinetic energy is the energy of its motion when it starts rolling. The sum of these is called mechanical energy. The heat in a hot object is the mechanical energy of its atoms and molecules in motion. In the 19th century, physicists realised that the heat produced by a moving machine was the machine’s gross mechanical energy converted into the microscopic mechanical energy of atoms. Chemical energy is another form of potential energy stored in molecular chemical bonds. It is this energy, stockpiled in your bodily cells, that allows you to run and jump. A battery converts chemical energy into electrical energy. Other forms of energy include electromagnetic energy, or light, and nuclear energy—the potential energy of the nuclear forces in atoms. A nuclear bomb converts nuclear energy into thermal, electromagnetic and kinetic energy. Fire is a conversion of chemical energy into thermal and electromagnetic energy via a chemical reaction that combines the molecules in fuel (wood, say) with oxygen from the air to create water and carbon dioxide. It releases energy in the form of heat and light. Even mass is a form of energy, as Albert Einstein’s famous \( E=mc^2 \) showed.

DIFFERENT TYPES OF STORED ENERGY

There are many more. We have harnessed many forms of stored energy to do useful work for us, relying on our understanding of theory, design and materials, that continue to be developed and improved over time, to contain and control these stored energies in a safe manner. Every day of our lives at home, when travelling and working, exposes us to the potential hazards associated with stored energy and the consequences of its uncontrolled release in the event of a component or system failure and/or human error. In the workplace, in order to limit the potential harm to ourselves, infrastructure and the environment a number of methods have been - and continue to be - developed and employed such as Manufacturing Quality Assurance & Control, Code of Safe Working Practices, Occupational Safety & Health, Workplace QHSE, Classification Society Rules, and Industry ISM Code.
A classification society is a non-governmental organisation that establishes and maintains technical standards for the construction and operation of ships and offshore structures. The society will also validate that construction is according to these standards and carry out regular surveys in service to ensure compliance with the standards.

In the second half of the 18th century, London merchants, shipowners, and captains often gathered at Edward Lloyd’s coffee house to gossip and make deals including sharing the risks and rewards of individual voyages. This became known as underwriting after the practice of signing one’s name to the bottom of a document pledging to make good a portion of the losses if the ship didn’t make it in return for a portion of the profits. It did not take long to realise that the underwriters needed a way of assessing the quality of the ships that they were being asked to insure. In 1760, the Register Society was formed — the first classification society and the one which would subsequently become Lloyd’s Register, to publish an annual register of ships. This publication attempted to classify the condition of the ship’s hull and equipment. At that time, an attempt was made to classify the condition of each ship on an annual basis. The condition of the hull was classified A, E, I, O or U, according to the state of its construction and its adjudged continuing soundness (or lack thereof). Equipment was G, M, or B: simply, good, middling or bad. In time, G, M and B were replaced by 1, 2 and 3, which is the origin of the well-known expression ‘A1’, meaning ‘first or highest class’. The purpose of this system was not to assess safety, fitness for purpose or seaworthiness of the ship. It was to evaluate risk.

Samuel Plimsoll pointed out the obvious downside of insurance: "The ability of shipowners to insure themselves against the risks they take not only with their property, but with other peoples’ lives, is itself the greatest threat to the safe operation of ships."

His efforts were directed especially against what were known as "coffin ships": unseaworthy and overloaded vessels, often heavily insured, in which unscrupulous owners risked the lives of their crews.

The first edition of the Register of Ships was published by Lloyd’s Register in 1764 and was for use in the years 1764 to 1766.

Bureau Veritas (BV) was founded in Antwerp in 1828, moving to Paris in 1832. Lloyd's Register reconstituted in 1834 to become 'Lloyd's Register of British and Foreign Shipping'. Where previously surveys had been undertaken by retired sea captains, from this time surveyors started to be employed and Lloyd's Register formed a General Committee for the running of the Society and for the Rules regarding ship construction and maintenance, which began to be published from this time.

In 1834, the Register Society published the first Rules for the survey and classification of vessels, and changed its name to Lloyds Register of Shipping. A full-time bureaucracy of surveyors (inspectors) and support personnel was put in place. Similar developments were taking place in the other major maritime nations.
The adoption of common rules for ship construction by Norwegian insurance societies in the late 1850s led to the establishment of Det Norske Veritas (DNV) 1864. RINA in Genoa, Italy in 1861 under the name Registro Italiano Navale, Germanischer Lloyd (GL) was formed in 1867 and Nippon Kaiji Kyokai (ClassNK) in 1899. Marine vessels and structures are classified according to the soundness of their structure and design for the purpose of the vessel. The classification rules are designed to ensure an acceptable degree of stability, safety, environmental impact, etc.

In particular, classification societies may be authorised to inspect ships, oil rigs, submarines, and other marine structures and issue certificates on behalf of the state under whose flag the ships are registered. To avoid liability, they explicitly take no responsibility for the safety, fitness for purpose, or seaworthiness of the ship.

### Development of the ISM Code

On the evening of March 6, 1987, the cross-channel Ro-Ro ferry Herald of Free Enterprise carrying more than 450 passengers, around 80 crew, more than 80 cars, and close to 50 freight vehicles, left the Belgian port of Zebrügge for the English port of Dover. Soon after the Herald of Free Enterprise passed Zebrügge's breakwater, water flooded into the ferry's lower car deck and destabilised it, causing it to sink in a matter of minutes. 193 lives were lost.

The immediate cause of the accident was that the bow door remained wide open, allowing a great inrush of water as the vessel increased speed, while the fatigued assistant boatswain directly responsible for closing it lay asleep in his cabin. The public inquiry led by Justice Sheen revealed that the assistant boatswain's negligence was simply the last in a long string of actions that laid the groundwork for a major accident. The Sheen Report did not stop at identifying the shortcomings of the ship's master and his crew. The inquiry revealed that the shore management, Townsend Car Ferries Ltd., was just as blameworthy. Numerous memos written by Townsend ship's masters pointing out the need to implement safety-enhancing measures or address serious deficiencies on board their vessels went unheeded (Rasmussen and Svedung, 2000). The report summed up the management's cavalier attitude towards safety in the following statement: 'From top to bottom the body corporate was infected with the disease of sloppiness' (Sheen, 1987).

The Herald of Free Enterprise was a modern ferry equipped with advanced technology and manned by a highly qualified crew. Only seven years prior to the accident, it was built in a German shipyard according to international maritime safety regulations. Why did it capsize? The general frustration in the shipping industry following the capsizing of the Herald of Free Enterprise is typical of the kind of accident that precipitated in a paradigm shift in maritime safety administration and the development of the ISM Code.

### Development of QHSE

The chemical industry introduced the first formal HSE management approach in 1985 as a reaction to several catastrophic accidents (like the Seveso disaster of July 1976 and the Bhopal disaster of December 1984). This worldwide voluntary initiative, called "Responsible Care", started by the Chemistry Industry Association of Canada (formerly the Canadian Chemical Producers' Association - CCPA), operates in about 50 countries. It may fit any type of organisation that has appeared in international standards such as:

- ISO 14001 for environmental management
- OHSAS 18001 for occupational health and safety management, first published in 1999
- The Eco-Management & Audit Scheme (EMAS), developed by the European Commission in 1993
Following a number of catastrophic disasters, we now abide by strict rules and guidelines that are designed to prevent history repeating itself, because we should know better, the lessons learned have been hard lessons, costing many lives and enormous sums of money.

ROAD MAP TO SAFETY

How do we manage these hazards today?

HIERARCHY OF CONTROL
Prevention is better than cure, as such the hierarchy of control determines application of effective control measures to achieve the safest possible outcome.

1. Eliminate
   (remove the cause of the danger completely)

2. Substitute
   (replace the hazardous work practice or machine with an alternative)

3. Isolate
   (separate the hazard from the people at risk from injury)

4. Engineer Controls
   (physical changes, e.g. redesign machine by adding safeguards)

5. Administrative Controls
   (install signs, rotate jobs, etc.)

6. PPE
   (provide gloves, earplugs, etc.)
ALARP PRINCIPLE
Using the ALARP principle – As Low As Reasonably Practicable – reducing residual risk to the barest minimum by identifying all potential hazards and applying appropriate controls, the ultimate goal is to reduce risk to absolute zero. Of course, practically this may not be achievable, as to eliminate risk entirely may involve time and cost which cannot be justified in terms of the benefits gained.

CARROT DIAGRAM
Can be used to map risks, by indicating high (normally unacceptable) risks at the upper/wider end and low (broadly acceptable) risks at the lower/narrower end. The region in between is sometimes called the ALARP region. However, this is misleading because ALARP refers to the principle of testing further risk reduction against the cost of this reduction effort, regardless of tolerability, and applies to all regions. A better name is the ‘tolerable region’, because risks in this region can sometimes be tolerated, if it can be shown that reasonable mitigations have been put in place. As below:

LOCK OUT TAG OUT (LOTO)
Isolation of hazardous stored energies can be achieved by physically locking off system isolation or drains/bleed points to prevent tampering, then tagging these points as a means of identification. Multiple locks can be employed to a single system isolation point when numerous tasks are being performed by different individuals on the same system, to ensure that no one person can return the system to normal operation, potentially risking injury to others.
It is essential to check that the system isolation and controls are effective before any work commences. It is widely understood that the person making the isolation should be the only person to remove the lockout on completion of work.
A LOTO register is essential to maintain an accurate record of system isolations that are currently in place or have been completed and the affected system returned to normal service.
Permits are effectively a means of communication between site management, plant supervisors and operators, and those who carry out the work. Examples of high-risk jobs where a written permit to work procedure may need to be used include hot work such as welding, vessel entry, cutting into pipes carrying hazardous substances, diving in the vicinity of intake openings, and work that requires electrical or mechanical isolation. It is also a means of coordinating different work activities to avoid conflicts.

Permit to work implementations usually use incompatible operations matrices. For example, to preclude one workgroup welding or grinding in the vicinity of another workgroup venting explosive or flammable gases.

The permit to work system is for work being performed in accordance with pre-approved procedures and that has been macro scheduled, the purpose is to prevent conflicting short term activities of different workgroups to prevent hazardous interference.
HISTORICAL EXAMPLES OF MANUAL PERMIT TO WORK FAILURES

USS Guitarro, a submarine of the United States Navy, sank alongside when two independent work groups repeatedly flooded ballast tanks in an attempt to achieve conflicting objectives of zero trim and two-degree bow-up trim; a result of failing to have a single person aware of and authorising all simultaneous activities by a permit to work system.

HMS Artemis, a submarine of the Royal Navy sank alongside when activities of ballast management and watertight integrity were uncontrolled and without oversight.

Occidental Petroleum’s Piper Alpha platform was destroyed by explosion and fire after a shift reinstated a system left partially disassembled by the previous shift. 167 men died in this incident due to failure to properly communicate permit state at shift handover.

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SO, HOW DO WE CONTROL HAZARDS IN THE WORKPLACE TODAY?

KEEP OUT THE UNDESIRABLES
Padlocked - Hazardous voltages cannot be accessed without proper authorisation and only by qualified personnel.

KEEP CLEAR - SIGNED AND SECURED
Rotating machinery and compressed air in secure area. No entry authorised personnel only.

SMOKING IS HAZARDOUS TO HEALTH
Flammables storied in a suitable lockable container. Potential vapours in vicinity can cause explosion. 3 m exclusion zone.

FULLY STACKED
No danger of collapse here. Extra touch with traffic cone placed to remind that a hazard exists.

IN CONCLUSION - WE CAN NEVER BE TOO SAFE. ALWAYS REMEMBER THE PRO MARINE SERVICES SAFETY ZONE - IF YOU ARE OUTSIDE WHAT DO YOU NEED TO GET BACK IN THE ZONE?

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