



Technical Specification

ISO/TS 20790

Oil and gas industries including lower carbon energy — Guidelines for green manufacturing and lower carbon emission of oil and gas-field equipment and materials

Industries du pétrole et du gaz, y compris les énergies à faible teneur en carbone — Lignes directrices pour une production verte et une réduction des émissions de carbone des équipements et matériaux des champs pétroliers et gaziers

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Foreword

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This document was prepared by Technical Committee ISO/TC 67, *Oil and gas industries including lower carbon energy*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

To meet the 2030 Sustainable Development Goals (SDGs), ISO/TC 67, representing the global oil and gas industries including lower carbon energy, plays an important role in reducing use of materials and other resources, increasing the recycling of resources, and reducing waste and emissions, e.g. greenhouse gas (GHG) emissions, while continuing to deliver the energy and products demanded by their consumers. The industry is committed to enhancing sustainability and to overcoming the world's most pressing sustainability challenges. The industry is aiming to take a more proactive role on both climate and health, safety and environment (HSE) performance issues.

There are opportunities throughout the oil and gas supply chain to increase positive impacts towards the SDGs. No matter how the energy transforms and how the industry develops, equipment, materials and other infrastructure serve as the foundation and the cornerstone for the development of the industry. Advanced materials, equipment and structures are the premises; they facilitate improvements in the efficiency of exploration and production, the safe and reliable operation of transportation and the continuous optimization of refining for oil and gas industries including lower carbon energy.

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Oil and gas industries including lower carbon energy — Guidelines for green manufacturing and lower carbon emission of oil and gas-field equipment and materials

1 Scope

This document provides guidelines for green manufacturing and lower carbon emission practices of oil and gas-field equipment and materials used in the hydrocarbon industries.

The guidelines include the establishment of a green attribute system and implementation of sound practices for green manufacturing and lower carbon emission, such as green design, manufacturing, remanufacturing, evaluation and management.

This document is applicable to organizations involved in the design, construction, engineering, commissioning, operations, maintenance, decommissioning and reuse of materials, equipment, installations and process systems applied in the hydrocarbon industries.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

sustainable development

development that meets the environmental, social and economic needs of the present without compromising the ability of future generations to meet their own needs

[SOURCE: ISO Guide 82:2019,^[1] 3.2, modified – Note 1 to entry has been removed.]

3.2

green economy

economy or economic development model based on the principles of *sustainable development* (3.1) and a recognition of the interdependence and coevolution of human economies and natural ecosystems over time and space

[SOURCE: ISO 6707-3:2022,^[2] 3.9.32]

3.3

full life cycle

expected period of time in which the product is expected to function according to manufacturer's specifications

[SOURCE: ISO 17078-1:2004,^[3] 3.17, modified — The wording has been adjusted according to the ISO/IEC Directives, Part 2.]

3.4

green manufacturing

manufacturing model in line with the concept of *sustainable development* (3.1) and *green economy* (3.2), the goal of which is to make the product consume fewer resources, have less negative impact on ecological environment, and finally realize the continuous coordination and optimization of economic and social benefits of organizations in the product *full life cycle* (3.3)

3.5

lower carbon emission

reduced carbon emissions compared to previous practices, by the implementation of *green manufacturing* (3.4) or the assistance in developing lower carbon energies

3.6

green design

design and development activities where the performance, quality, development cycle and cost factors are optimized so as to meet the goal of *green manufacturing* (3.4)

3.7

green processing

advanced technologies or practices adopted in the process of product manufacturing with the aim of reasonable utilization of resources, cost saving and environmental pollution reduction

3.8

remanufacturing

process of upgrading the equipment and materials so that the quality characteristics are not lower than that of the prototype new product

3.9

remanufacturing rate

percentage of the sum of the value of the remanufactured component to the value of the entire device or product

3.10

reutilization

process of using disused equipment and materials that are also of value for other purposes, either directly or after treatment

3.11

reutilization rate

mass fraction of the reutilized part to the total amount of scrap equipment and materials

3.12

recycling

process of treating previously used equipment and materials so that they can be reused as raw materials

3.13

recycling rate

mass fraction of the recycled part to the total amount of scrap equipment and materials

3.14

green attribute

characteristic of reducing materials and energy and reducing the ecological environmental impacts in the product *full life cycle* (3.3)

3.15

green assessment

evaluation and judgment of whether the *green attribute* (3.14) of the product meets the requirements of a standard or agreement

3.16

green supply chain

supply chain system that integrates *green manufacturing* (3.4) practices into its entire process, including the logistics process after product disuse

4 General

Green manufacturing and lower carbon emission are two important topics which should be considered together for the sustainable development of equipment and materials.

NOTE 1 Green manufacturing in the oil, gas and lower carbon energy areas supports the guidance for addressing climate change and sustainability concerns in ISO Guide 64,^[4] ISO Guide 82^[1] and ISO Guide 84^[5].

NOTE 2 Green manufacturing and lower carbon emission are related to the full life cycle of the equipment and materials. For a specific organization, they can only be involved in some areas of the design, construction, engineering, commissioning, operations, maintenance, decommissioning and reuse, etc.

Green manufacturing is the main method to realize lower carbon emission in equipment and materials, including the following aspects:

- in the traditional hydrocarbon industries, by adopting green design, green manufacturing and recycling, etc., to reduce the consumption of resources and energy, increase the utilization efficiency of resources and energy, and reduce the adverse effects of carbon emissions; and
- in the evolving lower carbon energy industries, by improving the performance of equipment and materials or by the research and development of new equipment and materials, to meet the needs of the development and utilization of new energy.

Low carbon emission is the main evaluation index of the green manufacturing effect of equipment and materials. From a macro perspective, the main ways to achieve carbon neutrality include carbon replacement, carbon emission reduction, carbon storage and carbon cycle.

For hydrocarbon equipment and materials, the specific measures that can contribute to green and lower carbon development are shown in [Table 1](#).

Table 1 — Main carbon reduction measures for hydrocarbon equipment and materials during the carbon neutralization process

Main ways for carbon neutrality	Measures	Specific measures for oil field equipment and materials
Carbon replacement	Wind, solar, electricity, geothermal, hydrogen, ammonia and biomass energy replace traditional fossil energy, etc.	Using lower carbon energy, or Updating or developing new equipment and materials to meet the development and utilization of lower carbon energy.
Carbon emission reduction	Save energy and improve energy efficiency, etc.	Energy saving, material saving, efficiency improvement and emission reduction
Carbon storage	Carbon capture, utilization and storage (CCUS), carbon capture and storage (CCS), etc.	Updating or developing new equipment and materials to meet the need of carbon storage.
Carbon cycle	Artificial carbon conversion, forest carbon sink, etc.	Developing new equipment and materials

The key for conducting sound practices for green manufacturing and lower carbon emission in the field of oil and gas-field equipment and materials are:

- to identify the green attributes and establish the green attribute system;
- to fully consider these attributes and take actions in the process of product full life cycle, including design, manufacturing, resource and energy cyclic utilization, etc.;
- to implement the evaluation and management of green attributes, and continuously improve them.

The overall approach is shown in [Figure 1](#).

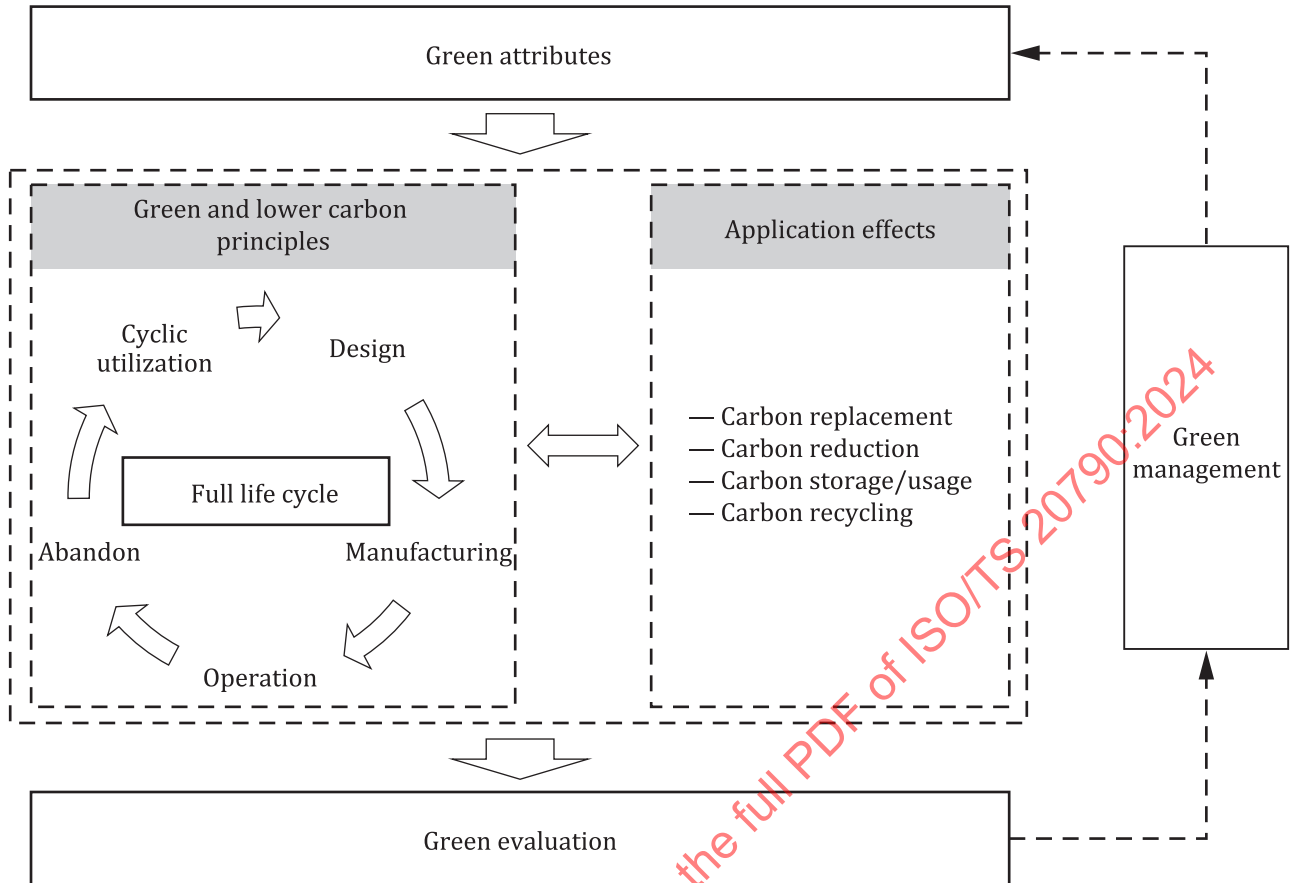


Figure 1 — Overall approach for green manufacturing and lower carbon emission

5 Green attributes

5.1 Principles for determination

5.1.1 General purpose

Green attributes should meet the needs of green design, manufacturing, remanufacturing, green evaluation and green management.

5.1.2 Operational and measurable

Green attributes should be measurable and comparable, easy to quantify, and have clear measurement indicators and referable standard requirements.

5.1.3 Systematic and specific

Green attributes should be specified and systematized based on the intrinsic value of the green manufacturing of the equipment and materials to clarify the content, measurement indicator and judgment basis of the green attributes.

5.2 Green attribute system

The implementation of green manufacturing of equipment and materials should reduce the consumption of resources and reduce the impact of ecological environment in the product full life cycle on the basis of satisfying product quality, production cost and production efficiency.

The green attributes are classified into two categories: resource attribute and ecological environment attribute according to the difference of the influence element and the intrinsic value of the green manufacturing of the oil field equipment and materials.

These two categories can then be divided into several sub-categories as shown in [Figure 2](#).

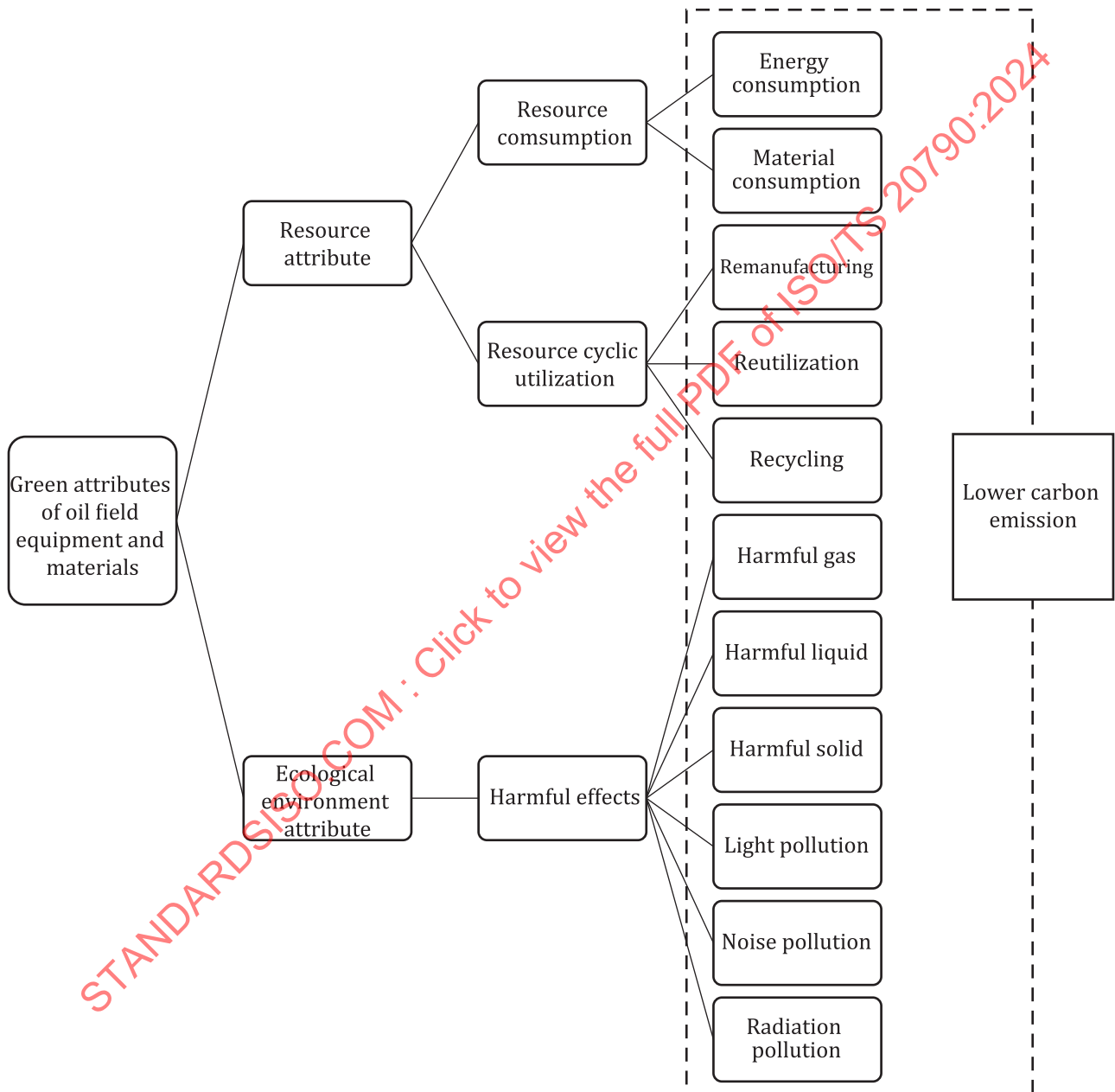


Figure 2 — Green attribute system

5.3 Green attribute content and measurement indexes

The green attributes and the contents and measurement indexes are shown in [Table 2](#).

Table 2 — Green attribute content, measurement indexes and referenced standards

No.	Attribute	Content	Measurement indexes ^{a,b}
1.	Energy consumption	Energy consumption at all stages of the product full life cycle.	Consumption Utilization rate
2.	Material consumption	Material consumption at all stages of the product full life cycle.	Consumption Utilization rate
3.	Remanufacturing	Process of upgrading of the oil field equipment and materials so that the quality characteristics are not lower than that of the prototype new product.	Remanufacturing rate
4.	Reutilization	Process of using disused oil field equipment and materials that are also of useful value for other purposes, either directly or after treatment.	Reutilization rate
5.	Recycling	Process of treating disused oil field equipment and materials so that they can be reused as raw materials.	Recycling rate
6.	Harmful gas	Greenhouse gases such as carbon dioxide, methane and toxic and harmful gases such as nitrogen dioxide, sulfur dioxide, VOCs, undergo no treatment or the treatment is not up to the standard.	Emission speed rate Emission concentration
7.	Harmful liquid	Waste water containing toxic and harmful substances, such as heavy metals, phosphorus, phenols, cyanide, oil, is discharged without treatment or the treatment is not up to the standard.	Emission volume Emission concentration
8.	Harmful solid	Solid waste containing toxic and harmful substances undergoes no treatment or the treatment is not up to the standard.	Emission volume Emission mass
9.	Light pollution	A strong light that affects the environment.	Light intensity
10.	Noise pollution	Noise that has impact on the environment.	Noise level
11.	Radiation pollution	All kinds of harmful radiation, including electromagnetic radiation, high temperature radiation, laser radiation, ultraviolet radiation, etc.	Radiation intensity Exposure time
^a Relevant international standards, national standards or other standards may be referenced for the requirements for the measurement indexes.			
^b The accounting of carbon can be used as a unified method to evaluate each attribute.			

6 Basic principles

6.1 General

To achieve the benefits of green manufacturing and lower carbon, principles from the perspective of full life cycle, from design, manufacturing, operation to cyclic utilization, should be followed.

For a specific organization or a specific activity, it's possible that they are not be involved in all life cycle phases, but only involved in one or more life cycle phases. However, they should consider the issues from the perspective of full life cycle, bearing these principles in mind and then cooperate with the related parties from the upstream or downstream.

6.2 Green design

6.2.1 General

The green attribute of the life cycle of equipment and materials, the technology and economy characteristics of the product should be considered comprehensively for maximized benefit.

Relevant policies, regulations, standards and stakeholder requirements should be taken into account, and the changes in these requirements should be reviewed and analysed on a regular basis.

The equal life design should be adopted on the premise of satisfying the working condition demand.

6.2.2 Materials

Priority should be given to:

- a) materials rich in source, non-toxic and harmless;
- b) remanufactured or recycled materials;
- c) materials easy to recover, recycle or biodegrade;
- d) materials with good compatibility.

The following materials should be restricted:

- rare materials;
- materials with unclear toxic and side effects;
- toxic, harmful materials but inevitable to be used;
- materials not easy to recover and recycle.

6.2.3 Structure

6.2.3.1 Standardization

The interchangeability of products should be increased through standardization and modular design.

6.2.3.2 Lightweight design

Lightweight design is adopted for the following reasons:

- a) the product is miniaturized to reduce the use of materials as well as the packaging materials;
- b) the structure is optimized to reduce the variety and quantity of parts;
- c) lightweight materials are preferred for motional parts.

6.2.3.3 Functional consideration

Product structure design should give priority to the use of clean and renewable energy.

The product structure should be conducive to improving the energy efficiency.

EXAMPLE Reasonable selection of motor, engine; improvement of mechanical transmission efficiency; improvement of energy conversion efficiency, optimization of system energy efficiency; adoption of frequency conversion control.

Auxiliary facilities such as energy metering, monitoring and energy recovery should be provided.

The effects of strong light, noise, vibration and radiation should be minimized. When necessary, noise suppression, noise reduction, protective cover and other safety protection facilities should be installed.

The production of toxic gas, liquid or solid should be minimized. When necessary, a recovery and purification device should be installed.

6.3 Green processing

6.3.1 Application of new processes

Process flow and process layout should be optimized to reduce intermediate links in production.

Process optimization design and evaluation should be carried out to phase out those process technologies and production equipment with low efficiency, high pollution, high energy consumption and other adverse effects.

Advanced technologies and equipment should be adopted, such as process simulation technology, digital processing, 3D printing, dry cutting, laser coating, and advanced casting, forging, heat treatment and surface processing with high efficiency, low consumption and clean features.

6.3.2 Resource consumption control

Clean and renewable energy should be used in priority during production.

The consumption of resources should be reduced and the utilization rate of resources should be improved in the production process, including the materials that make up the product, auxiliary materials, water resources and energy, etc.

The qualified rate of products should be improved and the generation of waste product and waste material in the production process should be reduced.

6.3.3 Emission control

Environmental pollutant emissions, including greenhouse gases, other harmful gases, harmful liquids, harmful solids, strong light, noise, radiation, etc., should be reduced and effectively controlled.

6.4 Operation process

The resource consumption and harmful effects emission should be monitored and measured during the operation of the equipment or systems.

Measures should be taken to lower the resource consumption and harmful effects emission.

During the operation of equipment or systems, a preventive maintenance plan should be developed to monitor the occurrence of technical warnings and reduce equipment failures caused by human factors through intelligent control.

6.5 Resource and energy cyclic utilization

The cycle utilization of resources such as remanufacturing, reutilization and recycling should be considered when the equipment or systems cannot fulfil the operation requirements.

A recycling system for waste oil and gas-field equipment should be established.

7 Typical practices

7.1 General

In practice, the relevant principles given in [Clause 6](#) should be applied to promote the green and lower carbon development of equipment and materials.

For a specific activity, it can contribute to either aspect of carbon replacement, carbon emission reduction, carbon storage, carbon cycle or others related with green manufacturing and lower carbon.

7.2 Practices mainly contributing to carbon replacement

7.2.1 Pure hydrogen or hydrogen-mixed pipeline transmission

The utilization of hydrogen energy is one of the most effective ways to achieve carbon replacement, and hydrogen as a clean energy source for future development has become a consensus.

There are two approaches to transporting hydrogen using pipelines: transporting pure hydrogen and its blending with natural gas transported via existing gas pipelines. Some of these pipelines should be repurposed into pure hydrogen pipelines later on. All of these prospects imply a number of technological challenges to be resolved.

Mixing hydrogen with natural gas and using the in-service natural gas transportation pipeline and its distribution network for transmission is one of the most promising ways to achieve safe, efficient, large-scale and long-distance transport for hydrogen to end users. After hydrogen is mixed into natural gas, the gas characteristics are more complex, which has an impact on the pipeline, transportation equipment, fuel equipment and so on. To promote the development of hydrogen energy, a series of applicable standards should be studied and established for the design, construction, operation and management of hydrogen-mixed natural gas pipelines, so as to form a targeted and integrated system for hydrogen-mixed natural gas pipelines.

The hydrogen-methane mixing ratio depends on the specific case and can vary over a wide range. Although hydrogen separation is a mature technology, the implementation of this process usually requires an individual cost-benefit calculation. The economic assessment of hydrogen blending should take into consideration pressure de-rating of existing pipelines, increased compression energy, increased pipeline maintenance spends, overall capital investments, as well as the economic effect of replacing natural gas with hydrogen as a fuel.

The features of pipeline transportation of hydrogen are determined by its physical and chemical properties, such as extremely low density, high permeability, high chemical activity towards other materials, significantly discrepant from those of natural gas.

Compared with steel pipes for hydrogen transport, non-metal pipes have many advantages, for example, strong design-ability, light weight, no risk of hydrogen embrittlement, and no welding, convenient and quick connection. On the other hand, it should be taken into consideration that hydrogen can impact the physical properties of plastic and composite materials penetrating in their structure and additional research and evaluation should be undertaken.

7.2.2 Underground hydrogen storage

Underground hydrogen storage (UHS) provides means to store large amounts of hydrogen at times when production exceeds demand, and for seasonal or daily retrieval of the stored hydrogen when demand exceeds production. UHS sites include geological formations such as salt caverns, aquifers, and depleted hydrocarbon reservoirs. In all UHS sites, access to the underground storage chambers is provided by access wells, which are completed with downhole tubular strings, similarly to oil-gas wells. In addition to access wells, observation wells are also constructed in porous-media storage sites such as depleted reservoirs, where they are used for integrity monitoring and leak detection.

Downhole tubular completions in access wells include casing and tubing strings that serve as conduits for hydrogen injection and retrieval, as well as barriers preventing hydrogen leaks into surrounding formations and ingress of formation fluids into the storage chambers.

To properly perform these functions, access well equipment and tubulars should exhibit structural strength and sealability under operational loading and over the well life-time.

Given that hydrogen reduces fracture toughness of steel alloys and is particularly detrimental to high-grade materials, tubular strings in access well should be constructed from materials inherently resistant to hydrogen, such as corrosion resistant alloys (CRAs). Alternatively, lower-grade steels with protective linings and coatings can also be used, whereby the steel portion of the string provides adequate structural strength and load-carrying capacity, and the lining/coating provides a barrier against hydrogen exposure.

In all cases, the design of access well completions and corresponding material selection should account for possible load-dependent and time-dependent material degradation, which can compromise the well integrity, disturb storage site operations, and negatively impact the surrounding environment. The well design and operational plan should also account for possible impacts following the well or site reconfiguration, re-purposing, decommissioning or abandonment. These considerations should be performed according to green evaluation principles outlined in [Clause 8](#).

7.3 Practices mainly contributing to carbon emission reduction

7.3.1 Application of low consumption and low emission power engine

The energy consumption and carbon emission of oil and gas equipment are mainly related to the power engine, so the power engine with lower consumption and lower emission should be used.

At present, the energy used in oil and gas equipment is mostly non-renewable energy or produces a large amount of carbon dioxide emissions during use. Clean and renewable energy sources, such as wind and solar energy, should be applied to oil and gas equipment; or traditional energy sources should be combined with new energy sources to reduce carbon emissions as much as possible.

The increase of the power grid coverage rate makes most of the oilfield operation areas accessible to the power grid and creates the conditions for the application of equipment using the network power. Getting power from the industrial power grid instead of diesel engine power, makes the drilling production process safer, more efficient and environmentally friendly.

7.3.2 Drilling rig potential energy recovery and application of energy storage

During the drilling operations, the winch drive hook and drill stem moves up and down. Main energy loss happens in the upward movement, and the potential energy accumulates. However, the released potential energy during the downward movement is not used; most dissipates in the form of heat, causing energy waste. It is conservatively estimated that the total energy consumption of the upward and downward movement can account for more than 20 % of the total energy consumption of the drilling process.

The large capacity capacitor should be used to convert the potential energy of the large hook and the drilling stem during the drilling process into electric energy and store it for the lifting of the drilling rig or other auxiliary equipment, to make full use of the energy and achieve the effect of energy saving.

7.3.3 "Well factory" large platform drilling

"Well factory" large platform drilling refers to an efficient and low-cost operation mode in which large numbers of similar wells are arranged in the same area and large amounts of standardized equipment or services are used for drilling and completion in the way of production or assembly line operations.

Through the layout scheme optimization of the "well factory" drilling platform, optimization design of the horizontal well track, sharing design of drilling equipment, etc., it can reduce land acquisition area, reduce oil base drilling fluid usage, improve drilling efficiency, reduce the cost of drilling engineering, and so on.

7.3.4 Coating for pipelines and storages

It is possible to take actions on 3 levels to improve the overall use of materials and energy in a "green" approach.

The first level of improvement is to promote the use of coatings that can allow the client to save energy, use green or "greener" energy. For example, the equipment or infrastructure can be designed to last longer without maintenance or needing replacement. This would be achieved by, amongst other design features, using appropriate anti-corrosion coatings or stronger mechanical coatings.

The second level of action is to act on the internal manufacturing processes to use less material and less energy. For example, a new coating can be adopted that takes significantly less time to get the work done with no higher energy consumption per unit of time.

The third level of action is to ensure that the plants, the warehouses, and the offices optimize the use of resources (electricity, water, heating system).

7.3.5 Remanufacturing

The production conditions of oil and gas industry are generally harsh, leading to the potentially early failure of a large number of parts of equipment and materials in the operation process due to mechanical wear, corrosion and other factors.

In the past, the failure parts were directly replaced to repair the equipment, resulting in additional expenses and forming a large amount of waste. Due to the lack of recognized specifications and effective management, some waste equipment is directly exposed to the environment and finally forms solid waste, causing serious pollutions to the air, soil and water.

It's estimated that about 80 % of the scrapped equipment can be remanufactured. Based on surface engineering and related advanced technologies, remanufacturing technology can restore the performance of the parts, or give them better wear resistance, corrosion resistance, high temperature resistance and other performance. Through the green remanufacturing technology, the old equipment takes on a new look and maximizes the use of the parts, showing the advantages and value of modern green technology.

EXAMPLE 1 Self-spreading repair technology can be used to repair the tubing, the nano brush plating technology can be used to remanufacture the plunger surface, and the laser cladding technology can be used to repair the reducer gearbox.

EXAMPLE 2 Tubing, pumping rod, plunger, reducer, engine and other oil and gas equipment can be remanufactured.

Many single products of oil and gas equipment have high value; and the overall market size is large. Remanufacturing can produce considerable economic value.

7.4 Practices mainly contributing to carbon storage

CCS refers to the capture of carbon dioxide produced by large thermal power generation, steel mills, chemical plants, etc., transported to the suitable place, and using technical means to isolate the captured carbon dioxide for a long time.

Geological storage is the main form of carbon storage, which is mainly for oil and gas reservoirs, deep underground salt water layer and abandoned coal mines. After the completion of oil and gas fields, the existing ground and underground facilities can be used for carbon dioxide storage.

In addition, the collected carbon dioxide can be converted and recycled to produce economic benefits, such as oil field flooding, synthetic biodegradable plastics, food preservation and storage, improving salt and alkali water quality, planting plants, etc., namely CCUS technology.

At present, the global carbon dioxide storage potential is huge. It is urgent to accelerate the breakthrough and advanced demonstration of CCS/CCUS technology, process and equipment, and promote the innovation and application of carbon dioxide utilization such as enhanced oil recovery, chemical or biological utilization.

7.5 Practices mainly contributing to others

7.5.1 Waste liquid treatment

In oil and gas exploration, drilling waste and produced water are the main typical sources of contamination generated during exploration and development of oil and gas fields. If not be treated properly, it can cause serious environmental risks to the surrounding soil, water, farmland and air.

The integrated drilling waste treatment device realizes the collection of drilling mud, liquid phase recycling, solid phase harmless treatment, and solid phase resource reuse.

The produced water of chemical flooding should be treated with clean medicament to reduce the production of polymer-bearing sludge. The produced water of chemical flooding can be used for reformulation of displacement fluid to make full use of the residual chemicals.

7.5.2 Materials used for aggressive environments

Titanium alloy, aluminium alloy, magnesium alloy and carbon fibre pipe have the advantages of low density, high specific strength, corrosion resistance and fatigue resistance. They are expected to play a significant role in the development of ultra-deep well, horizontal well and large displacement well.

Products like bimetal composite pipes, medium and low Cr corrosion resistant alloy tubes, new coated pipes, high temperature resistance (temperature resistance above 80 °C) non-metal and composite pipes, have good corrosion resistance and economy, can reduce material corrosion, reduce the use of precious metals, and meet the development of oil and gas fields in harsh conditions such as acidic environment oil and gas fields.

For the development of natural gas hydrate, titanium alloy pipes and new surface coating materials are developed and applied to solve bottleneck problems such as leg penetration and hydrate blockage; for underground coal gasification, combustible casing and tool materials with high temperature corrosion resistance are developed to solve the integrity problems, like casing deformation and corrosion perforation; for geothermal development, drilling tools and material systems with high temperature resistance are developed for deep and high temperature conditions.

Examples of green processes and techniques for oil and gas equipment and materials are given in [Annex A](#).

8 Green assessment

8.1 Green assessment content

For one or more of the green attributes in [Figure 2](#) and [Table 2](#), a green assessment should be performed using one or more of the methods in [8.2](#).

8.2 Green assessment methods

8.2.1 Life cycle assessment method

The data of energy, material consumption and waste discharge in the product full life cycle from raw materials acquisition, production, storage, transportation, use to the end of life, circulation and final disposal are collected, analysed and quantified; the potential environmental impact is evaluated; the design scheme and manufacturing process are improved; and the green manufacturing of equipment and materials is realized.

The life cycle assessment consists of the following four phases.

- a) Determination of purpose and scope: the purpose of the evaluation should be determined first, and the scope of the evaluation should be determined based on the product characteristics and evaluation purpose of the evaluation.
- b) Inventory analysis: this stage compiles and quantifies the input and output of the full life cycle of the evaluation object, which is the key stage of the life cycle assessment.
- c) Impact evaluation: based on the results of the inventory analysis, the extent and importance of potential environmental impacts throughout the life cycle of the evaluation object are evaluated.
- d) Explanation: considering the process of inventory analysis and impact evaluation, the important input, output and selection of method are evaluated, the sensitive and uncertainty are checked, and the conclusions, suggestions and their limitations are explained.

[Annex B](#) gives examples of inventory analysis, calculation of greenhouse gas impact potentials and product full life cycle green assessment. ISO 14067^[6] and ISO 14046^[7] provide guidelines related to carbon footprint and water footprint assessment individually based on life cycle assessment. For the detailed operation of the life cycle assessment method, ISO 14044^[8] should be referenced.

8.2.2 Other methods

Other applicable evaluation methods can also be adopted, such as analytic hierarchy process (AHP) and fuzzy comprehensive evaluation method.

9 Green management

9.1 Basic ideas and process

The green property of the product should be incorporated into the applicable management system (quality, environment, resources, information management system, etc.) as an important characteristic of the product.

To realize the green procurement and sustainable development of enterprises:

- the concepts of green manufacturing, product life cycle management and extended producer responsibility should be integrated into the enterprise supply chain management system;
- the green attributes of each stage of the product life cycle should be identified;
- the green attributes of products or materials should be effectively managed in coordination with suppliers, manufacturers, logistics providers, sellers, users, recyclers and other entities in the supply chain.

The basic process of green supply chain management is shown in [Figure 3](#).

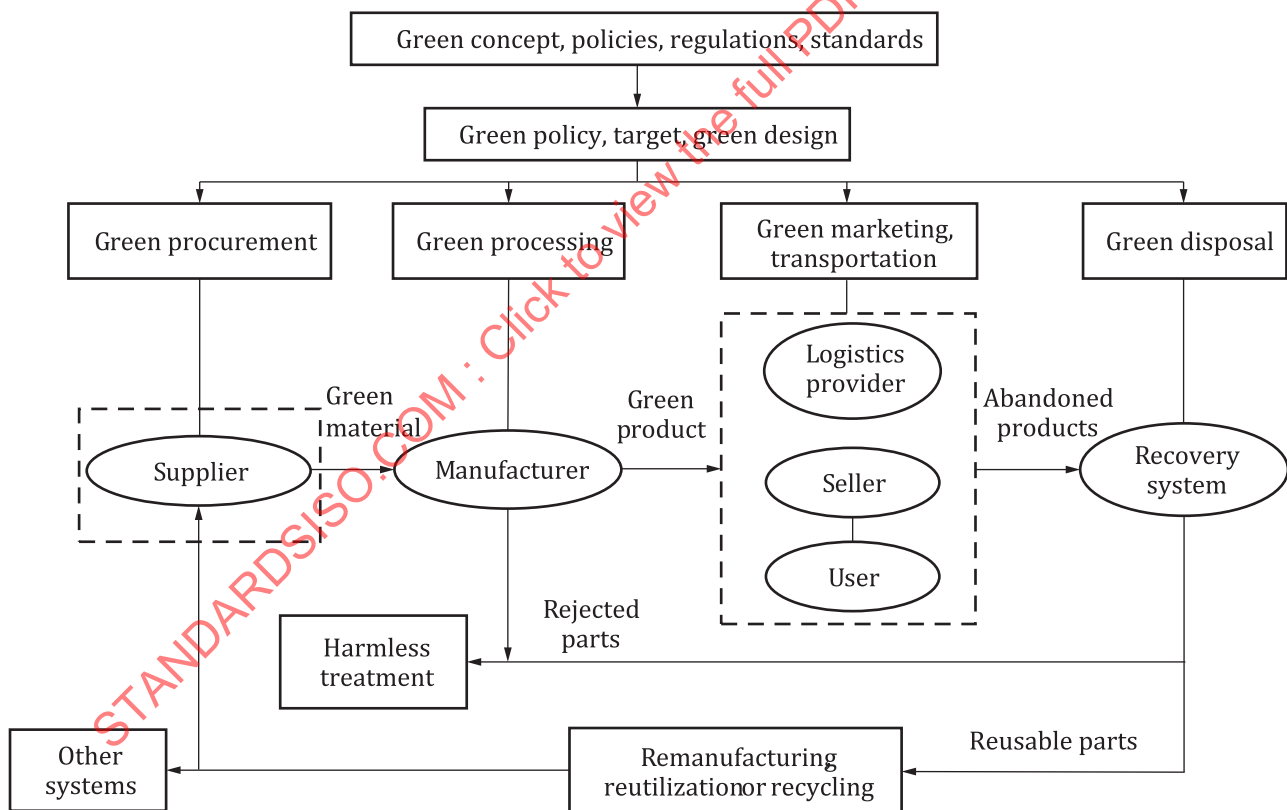


Figure 3 — Basic process of green supply chain management

9.2 Recommendations for the related parties

A green supply chain management policy and quantifiable, measurable management objectives should be developed, including the following.

- The enterprise green procurement process should be established and the cooperative improvement measures of the supply chain should be formulated. Priority should be given to the purchase of green-produced oil field equipment and materials.
- The enterprise green manufacturing process should be established and the cooperative improvement measures of the supply chain should be formulated. Green manufacturing should be carried out to improve the green degree of oil field equipment and materials.

An effective organization should be established and the necessary human, financial, equipment, information and knowledge resources should be provided, or existing institutions and resources should be integrated to meet the needs of green supply chain management.

Employees should be trained with green supply chain management awareness, knowledge and ability, and relevant information should be communicated to all relevant parties in supply chain in time, so that green supply chain management requirements can be understood and supported by the employees and related parties.

Relevant process management procedures and standards for the product full life cycle should be established.

9.3 Product documentation

Contents about green material, green attribute and special process requirement should be added to product-related documents.

The following statements should be given in the product specifications or relevant documents:

- a) toxicity and final disposal of product materials;
- b) use of recycled materials and remanufactured parts;
- c) product disassembly, material recycling and remanufacturing.

9.4 Identification

For product conforming to the green manufacturing requirements, a clear green manufacturing identification should be marked on the product, product specification, or product package (if applicable).

EXAMPLE Recycling symbol in ISO 7001^[9].

Suppliers should demonstrate that the products and services with green manufacturing identification meet relevant regulations and standards.

Annex A

(informative)

Examples of green processes and techniques

[Table A.1](#) provides examples of green processes and techniques for equipment and materials.

Table A.1 — Examples of green processes and techniques

No.	Main area	Green process and technology	Content
1.	Carbon replacement	Increasing the consumption of natural gas, green electricity, and green hydrogen	Changing the fuel heating furnace to an electric heating furnace, compressor steam drive to electric drive, and hydrogen production from natural gas to renewable energy.
2.	Carbon replacement	Constructing a high-efficient re-electrification process to improve energy efficiency	Like replacing centralized gas heating with decentralized electric heating, utilizing heat pump technology to make full use of low-temperature thermal resources in oilfield, exploring front-end on-site water discharge processes and high-efficient electric strengthening treatment technology and equipment.
3.	Carbon replacement	Green hydrogen production by coupling electrolysis of water and production of electricity through renewable energy	Due to the challenge of fluctuation and discontinuity of green electricity, extending the service life of the electrolytic cell device, and promoting the development of large-scale hydrogen storage through technological innovation.
4.	Carbon replacement	Hydrogen storage	Storing hydrogen on-site in depleted oil and gas fields or blending it into natural gas pipelines can achieve low-cost storage and transportation.
5.	Carbon replacement	Geothermal resources development	Transforming a large number of abandoned or inefficient oil wells into geothermal wells for geothermal resources development.
6.	Carbon replacement	Promoting the use of ammonia	As a clean energy source, it has the potential to become an alternative fuel for engines. It is a good fuel for fuel cells and an efficient and safe hydrogen carrier. Integrating renewable energy with the hydrogen energy industry, using ammonia as a storage or hydrogen carrier, to promote the clean and efficient synthesis of ammonia, economically safe ammonia energy storage and transportation, and carbon free and efficient utilization of ammonia and hydrogen.
7.	Carbon emission reduction	Lightweight design	The development and application of X80 and above high strength pipeline steel; improvement the strength design coefficient of gas pipeline (e.g. 0,8 design coefficient).
8.	Carbon emission reduction	Application of new materials, new processes, new technologies, and new equipment	Accelerating the research, development, promotion and application of new materials, new processes, new technologies, and new equipment such as molecular refining, high-efficiency catalysts, hyper-gravity, micro-reactor, membrane separation, energy conservation and environmental protection.
9.	Carbon emission reduction	Recycling of waste materials	Promoting the recycling of waste plastics, waste rubber and other materials.
10.	Carbon emission reduction	Reutilization of oil and gas-field equipment and materials	The reutilization of oil and gas-field equipment and materials, for example, the equipment and materials previously used in aggressive working conditions, after simple treatment and inspection, may be used in places with better working conditions.

Table A.1 (continued)

No.	Main area	Green process and technology	Content
11.	Carbon emission reduction	Transformation and upgrading of refineries	Promoting the transformation and upgrading of refineries, eliminating outdated production capacity, and promoting the construction of large-scale, integrated, and intensive production capacity.
12.	Carbon emission reduction	Reduction of energy consumption and emissions, improvement of process efficiency and intelligence	Through the promotion or adoption of heating furnace efficiency improvement, oxygen-rich combustion, energy system optimization, advanced process equipment and other advanced technologies, reducing energy consumption and emissions, improving process efficiency and intelligence.
13.	Carbon emission reduction	Energy system optimization	Carrying out energy system optimization work to make full use of oil, gas and lower carbon energies.
14.	Carbon emission reduction	Recovery of process waste heat and residual pressure	Adopting heat pump, thermal combination and other technologies to strengthen the recovery of process waste heat and residual pressure.
15.	Carbon emission reduction	Construction of smart oil and gas fields	Accelerating the construction of smart oil and gas fields, integrate information technologies such as big data and artificial intelligence with oil and gas field expertise, creating an intelligent optimization and control system of energy, and achieving energy refinement, intelligence, and digital control.
16.	Carbon emission reduction	Improving the conversion efficiency	Improving the carbon and hydrogen conversion efficiency from raw materials to products, and reducing the demand for fossil fuels.
17.	Carbon emission reduction	Conducting carbon emission management	Improving carbon emission management to achieve emission reduction, low emission, and zero emission.
18.	Carbon emission reduction	CO ₂ emission inspection and accounting	Carrying out CO ₂ emission inspection and accounting in the whole industry chain, and improving the information level of measurement for key emission sources.
19.	Carbon emission reduction	Promoting methane emission control	In the oil and gas production process, a small amount of methane leakage can occur in separators, wellhead devices, dehydrators, etc., and carbon emissions during the operation of these devices can be reduced through detection or recovery devices.
20.	Carbon storage	Hydrogen production combined with CCS technology	The technology of hydrogen production from fossil energy is mature and low cost, but there is a problem of large carbon emission, which needs to be combined with CCS technology.
21.	Carbon storage	Developing low-cost CO ₂ capture technology	Accelerating the experimental demonstration of low-cost CO ₂ capture technology and chemical utilization of CO ₂ in key carbon emission devices such as catalytic cracking and hydrogen production.
22.	Carbon storage	Developing CCUS supporting technologies	In view of the problems such as "wellbore corrosion perforation and casing leakage" in the CCUS test area, new technologies are adopted such as new gas sealed casing, CO ₂ corrosion resistant cement, and coiled tubing gas injection technology.
23.	Others	Application of new materials/products	Not using cutting fluid, thread compounds and other products that may be harmful to the environment.
24.	Others	Green cleaning	According to the structure of the components and the characteristics of the pollutants, the proper cleaning method is adopted, so that the components are not damaged, and the components are thoroughly and environment-friendly cleaned, such as hydraulic line high-efficiency cleaning technology, laser cleaning and high-temperature steam cleaning used in the remanufacturing.