INTERNATIONAL STANDARD

ISO 13628-3

First edition
2000-12-15

Petroleum and natural gas industries — Design and operation of subsea production systems

Part 3: Through flowline (TFL) systems

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Industries du pétrole et du gaz naturel — Conception et exploitation des systèmes de production sous-marins

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Partie 3: Systèmes d'injection TFL

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Reference number
ISO 13628-3:2000(E)

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Printed in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 13628 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13628-3 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

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ISO 13628 consists of the following parts, with the general title *Petroleum and natural gas industries — Design and operation of subsea production systems*:

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— *Part 1: General requirements and recommendations*

— *Part 2: Flexible pipe systems for subsea and marine applications*

— *Part 3: Through flowline (TFL) systems*

— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea control umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Workover/completion riser systems*

— *Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

— *Part 9: Remotely Operated Tool (ROT) intervention systems*

Annex A forms a normative part of this part of ISO 13628. Annexes B, C and D are for information only.

Introduction

This part of ISO 13628 is based on API RP 17C:1991 [5].

The TFL systems and tools described herein permit both horizontal transport and vertical entry into the wellbore.

Users of this part of ISO 13628 should be aware that further or differing requirements may be needed for individual applications. This part of ISO 13628 is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this part of ISO 13628 and provide details.

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Petroleum and natural gas industries — Design and operation of subsea production systems

Part 3:
Through flowline (TFL) systems

1 Scope

This part of ISO 13628 specifies requirements and gives recommendations for the design, fabrication and operation of TFL equipment and systems.

The procedures and requirements presented are for the hydraulic servicing of downhole equipment, subsea tree and tubing hanger, and flowlines and equipment within the flowlines.

This part of ISO 13628 primarily addresses TFL systems for offshore, subsea applications but it may also be used in other applications such as highly-deviated wells or horizontally-drilled wells.

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Subsea separation, boosting, metering and downhole pumps are outside the scope of this part of ISO 13628.

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2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13628. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13628 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3183-1, *Petroleum and natural gas industries — Steel pipe for pipelines — Technical delivery conditions — Part 1: Pipes of requirement class A.*

ISO 11960, *Petroleum and natural gas industries — Steel pipes for use as casing or tubing for wells.*

ISO 13628-4:1999, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 4: Subsea wellhead and tree equipment.*

API RP 14E, *Design and Installation of Offshore Production Platform Piping Systems.*

API Std 1104, *Welding of Pipelines and Related Facilities.*

3 Terms, definitions and abbreviated terms

For the purposes of this part of ISO 13628, the following terms, definitions and abbreviated terms apply.

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3.1 Terms and definitions

3.1.1
bend radius
radius of curvature as measured to the centreline of a conduit

3.1.2
circulation control valve
valve normally placed across the circulation point to allow isolation of the tubing strings or tubing/casing during production

3.1.3
circulation point
location where communication is established between supply and return fluids for TFL servicing

3.1.4
diverter
device used to direct tools at a branch connection

NOTE Used generically, it refers to that category of equipment which includes deflectors, diverters and selectors.

3.1.5
drift
gauge used to check the minimum radius of curvature and minimum ID of loops, flowline and nipples

3.1.6
H-member
nipple assembly that provides fluid communication and circulation between strings of tubing in the wellbore

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3.1.7
loop
curved section of pipe allowing change in direction of TFL flowlines

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3.1.8
lubricator
tube and valve assembly that permits tool-strings to be inserted into and removed from a pressurized system

3.1.9
parking system
system whereby tools/equipment for a particular tubing size are transported through a flowline of a larger size by a transport (carrier) piston string which is left behind or "parked" outside the well while the remaining equipment continues into the tubing

3.1.10
profile
internal conduit configuration (receptacle) used to engage tools

3.1.11
recess
enlargement in conduit bore, normally concentric with the bore

3.1.12
sealing bore
polished section of conduit that receives a packing element

3.1.13
flowline
service line
line from a platform or land facility to a subsea facility used for TFL servicing

NOTE It may also be used for production or other testing of the well.

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3.1.14
flowline signature
service line signature
particular set of pressure pulses (spikes) read or recorded at the surface that identifies a certain point in the service/flowline or well as tools are pumped past

3.1.15
subsea tree
christmas tree placed at the seabed

3.1.16
TFL piping system
all piping from the surface lubricator through the flowline and tubing to the deepest point in the well to which TFL tools can be circulated

3.1.17
tubing-retrievable safety valve
downhole safety valve run in the well on tubing

NOTE It is normally surface-controlled and has an ID close to the size of the tubing bore, thereby providing an almost unrestricted bore.

3.1.18
wye spool
piping section of a subsea tree where the loop joins the vertical tubing bore

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3.2 Abbreviated terms

BHP bottom-hole pressure

CCV circulation control valve

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EUE external upset end

ID inside diameter

OD outside diameter

SDC side door choke

SCSSV surface-controlled subsurface safety valve

SVLN safety valve landing nipple

TFL through flowline

TRSV tubing-retrievable safety valve

TMD total measured depth

TVD true vertical depth

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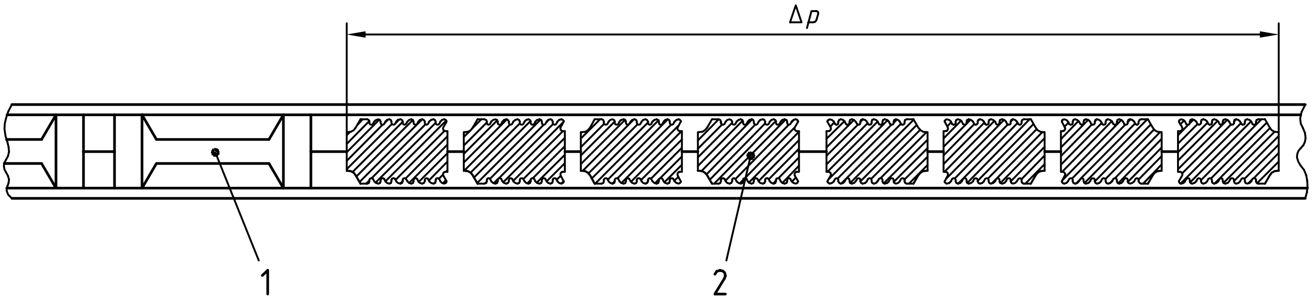
4 TFL system

4.1 Description of system

The TFL method allows various well servicing operations to be performed by utilizing fluid to transport tools through flowlines and loops into and out of tubing strings. The differential pressure of the transport fluid across the tool-string provides the force required to perform the various operations as shown in Figure 1.



Key

1 Tools

2 Pistons

Figure 1 — Differential pressure, Δp

4.2 TFL components

Figure 2 is a representation of a typical TFL system. The basic components of a system include the surface equipment, flowlines, subsea tree, TFL service tools and associated downhole equipment. The function of this system is to provide the means of transport and control of TFL tools. The transportation of tools is provided by the pumping equipment while the control of these tools is provided by the pumping rate, instrumentation and TFL control manifold. The basic criteria of a TFL system are

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— to have an appropriate pressure rating for the system;

— to provide necessary volumes of fluid required by the TFL operations;

— to control the equipment within operating specifications.

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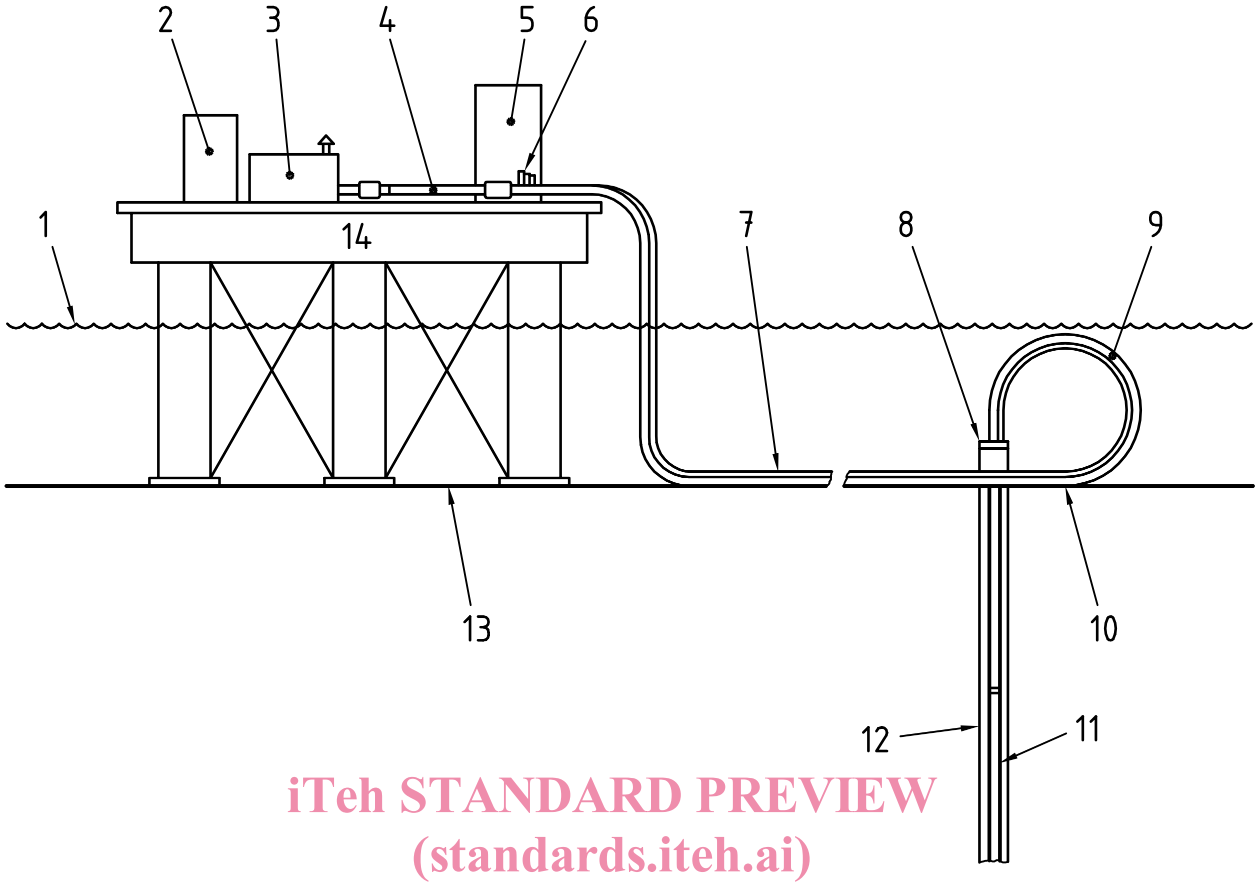

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Key

1 Water
2 Tank
3 Pump
4 Lubricator
5 Manifold and instrumentation
6 Pressure transducers
7 Flowline/service line
8 Subsea tree
9 TFL bends
10 Subsea wellhead
11 Circulation point (H-member)
12 Well
13 Mudine
14 Platform

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Figure 2 — Typical offshore TFL installation

4.3 System/equipment design

TFL tools (see Figure 3) have been designed to operate in various tubing sizes commonly used in subsea wells. TFL tool design is dependent upon the tubing ID and the minimum radius of curvature of tube bends. The design of a TFL piping system shall take into account the internal diameters of the conduit and receptacles and the pressure ratings of the pipe and tubing. The ID of the service line should be the same as the ID of the downhole tubing strings, otherwise it should incorporate a parking system. If the ID is too large, fluid will bypass the tool-string piston units, reducing their force capability and resulting in inaccurate measurement of tool position. Conversely, if the ID is too small it can prevent tool passage, can cause excessive drag or can damage and wear the tool, seals and piston units.

Annex A specifies the requirements for TFL pipe and Table A.1 lists pipe ID dimensions that are compatible with tubing sizes.

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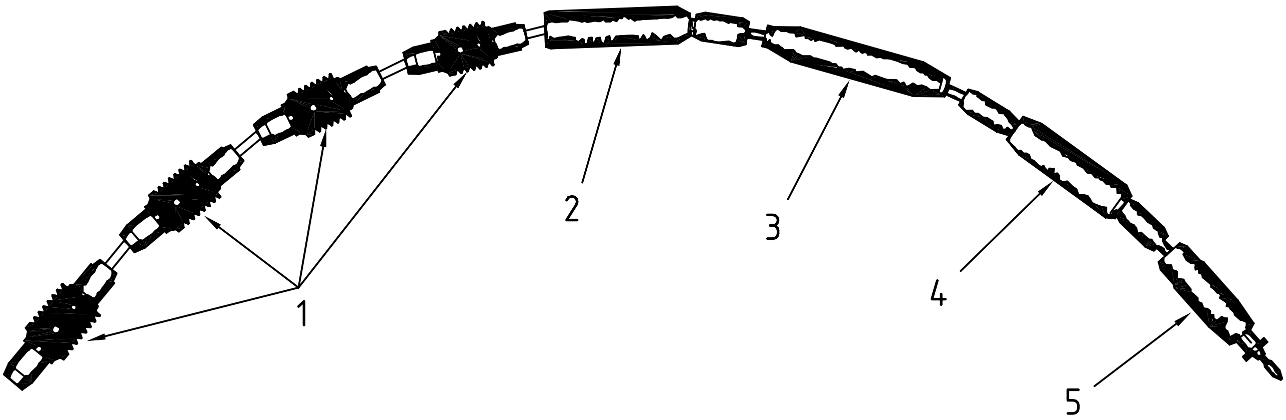

Key

1 Piston units
2 Accelerator
3 Stem
4 Hydraulic jar
5 Pulling tool

Figure 3 — Typical TFL service string

4.4 Pressure rating

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The pressure rating of a TFL system shall be greater than the maximum pressure to be encountered during TFL operations throughout the life of the installation. As a guide, consideration should be given to practical combinations of the following:

— maximum static bottom-hole pressure of the well, minus the hydrostatic pressure of the fluids in the TFL system;

— pressure to overcome frictional losses when circulating fluids and tool-strings;

— pressure required to operate all the TFL devices. This includes not only service tools but also downhole isolation and plugging equipment;

— hydraulic shocks or surges in the system which may occur during operations such as jarring;

— pressure required to kill the well if the TFL system is to be used to pump well kill fluids into the producing formation.

Multiple-well systems shall consider the effect of the higher pressure wells in the system.

Additional information about the system pressure rating and TFL fluids is provided in clause 9 and annex B.

5 TFL surface equipment

5.1 General

TFL surface equipment (see Figure 4) includes a service pump, TFL control manifold, TFL control console, lubricator, fluid storage, separator and piping system. The pump pressure and flow rating should be compatible with the design of the system, taking into account the tool transport speeds referenced in clause 9 (see Table 1), tool-string actuation pressures and the fluid bypass that may occur during these operations. Sufficient volume (see 5.6) should be provided in the tanks and tubing strings to assure that all operations can be handled effectively. The surface facility (see Figure 5) should provide space to accommodate the TFL facilities, and the equipment

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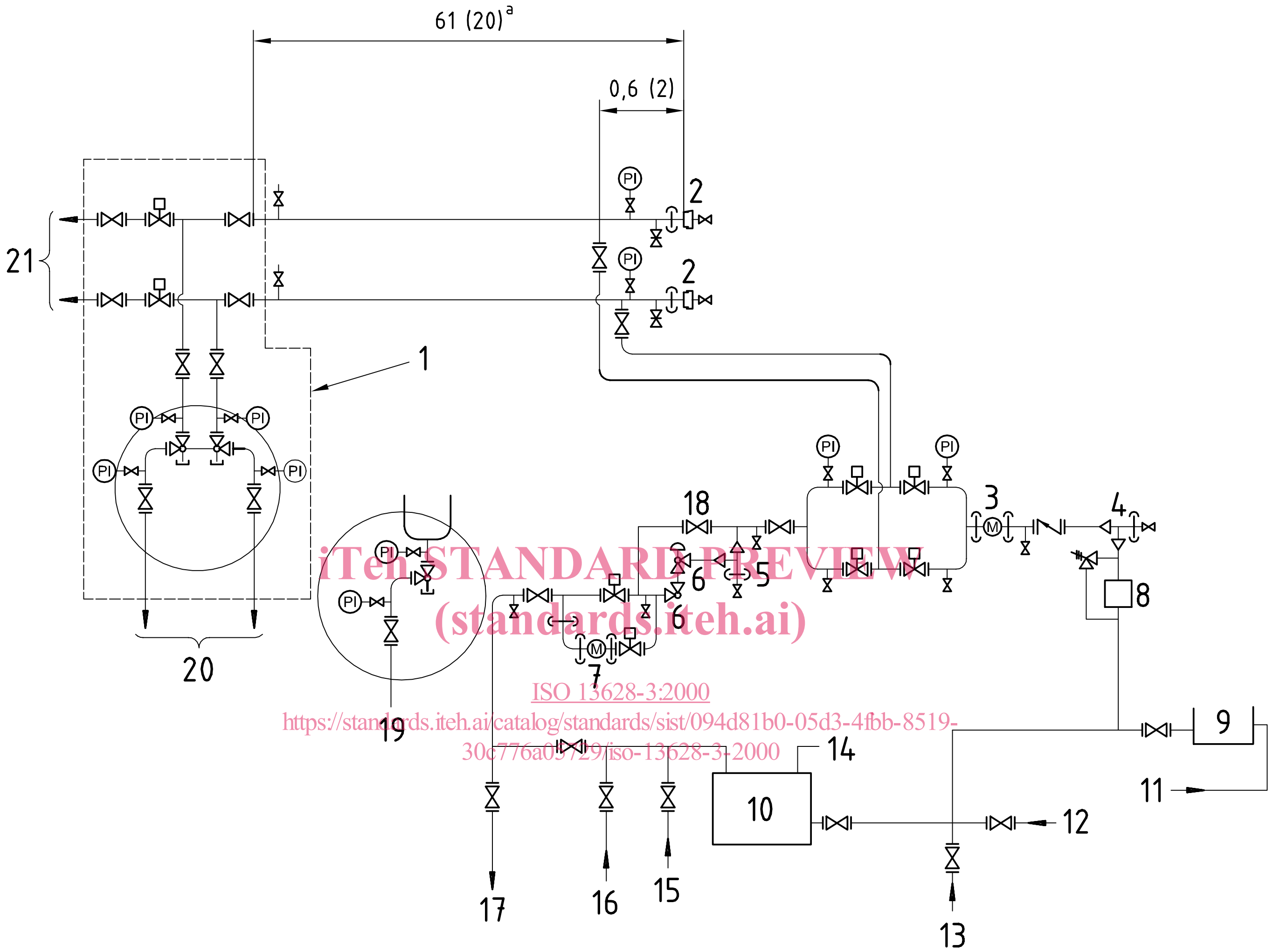
layout should be arranged with due regard to the proximity of the control console, pump, manifolding and lubricator, and the space needed to easily insert and remove extended-length tool-strings. If this equipment is located on a drilling/production platform, the use of basic platform equipment (such as high-volume mud pump or kill pump) may eliminate the need for dedicated equipment.

Dimensions in metres (ft)



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Key

1 Production control manifold
2 Threaded quick connection with plug
3 Flowmeter
4 High pressure strainer
5 High pressure strainer
6 Choke
7 Flowmeter
8 High pressure/high volume triplex pump
9 795 l (5 BBL) open tank
10 Working tank
11 From platform saltwater system (optional)
12 From mixing tank
13 From dry oil tank (optional)
14 Gas blanket
15 Fill-up line
16 From separator liquid dump
17 To separator
18 Optional valve
19 Optional surface choke arrangement
20 To production manifold
21 To well

[a] Recommended minimum straight level section.

Figure 4 — Example of TFL platform piping

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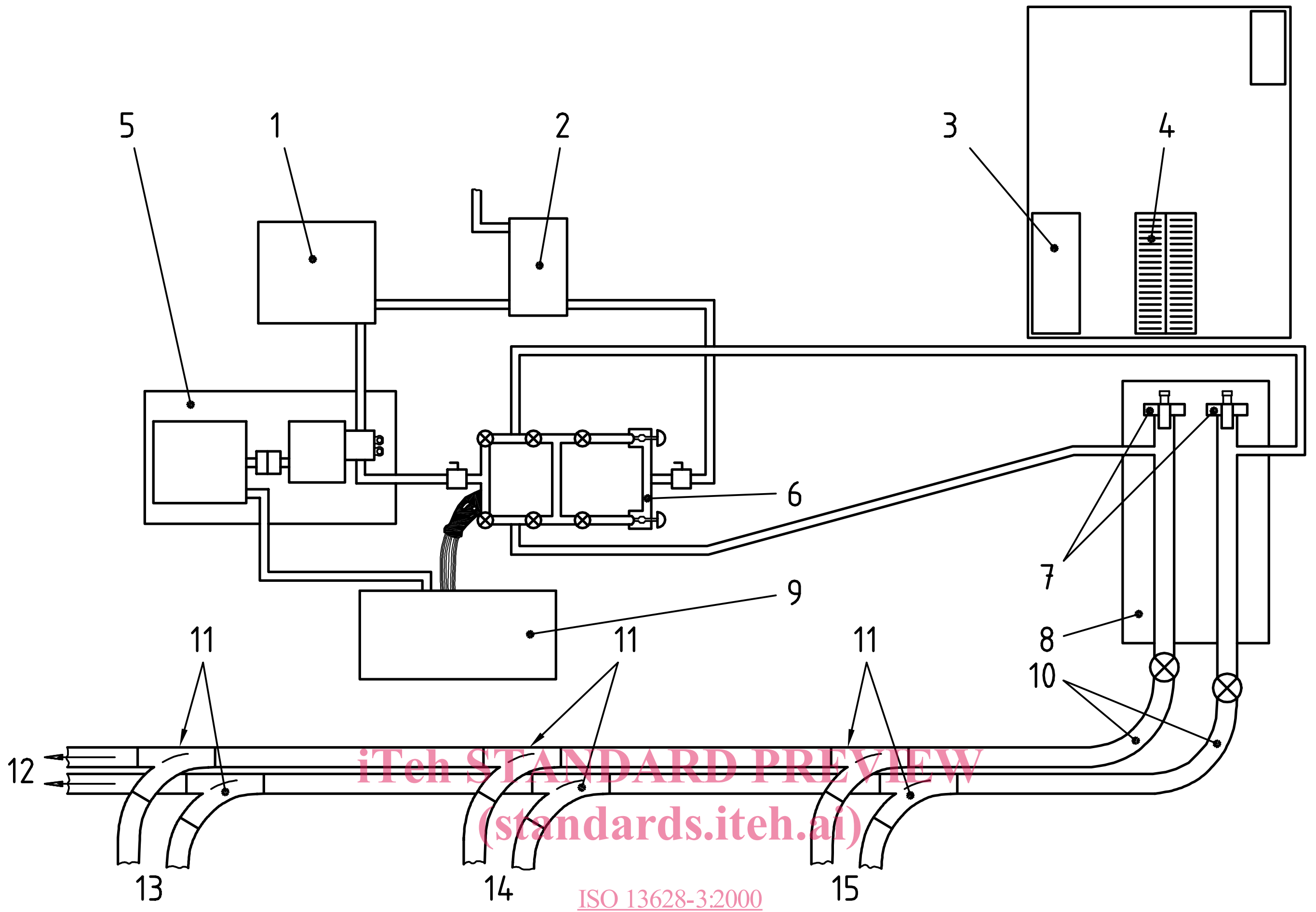

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Key

1 Fluid mixing tank
2 Storage tank
3 Work table
4 Roller table
5 Pump unit
6 Surface control manifold
7 Tool feeders
8 Dual horizontal lubricator
9 Control console
10 Entry loops
11 Diverters
12 To other wells in system
13 Well 3
14 Well 2
15 Well 1

Figure 5 — Typical surface equipment arrangements for installations

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Table 1 — Recommended flow rates for TFL tools

Feature	Nominal tubing ID mm (in)				
	50,8 (2)	63,5 (2 1/2)	76,2 (3)	101,6 (4)	127 (5)
	Flow rate l/min (bbl/min)				
Tool transport	318 (2,0)	477 (3,0)	636 (4,0)	795 (5,0)	954 (6,0)
Restricted line (max.)	159 (1,0)	159 (1,0)	318 (2,0)	318 (2,0)	318 (2,0)
Locating and landing (max.)	79,5 (0,5)	79,5 (0,5)	159 (1,0)	159 (1,0)	159 (1,0)

5.2 Service pump

Generally, triplex-type positive displacement pumps have been used for TFL operations although slow speed duplex and high-pressure multi-stage centrifugal pumps have also been successfully used by some operators. The primary recommendations for the pumps are as follows:

- pressure and flow rate capability should be in accordance with clause 9;
- a relief valve should be provided on the pump discharge to protect the pump and piping system against over-pressure or hydraulic shocks and surges;
- pump suction piping should have connections for auxiliary tanks or mixing facilities;
- the TFL pump drive should be designed to allow smooth changes to be made over the range of operating conditions described in clause 9.

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5.3 TFL control manifold

Valving arrangements shall be designed to direct pump flow and fluid return to the service lines, tanks, separators, etc., as needed to perform TFL operations. Piping and valves should be capable of handling the maximum working pressure of the system. Valves and actuators should be selected to permit rapid line switching (i.e. within 2 s or less). Valving should provide for return of fluids through an adjustable back pressure regulator or choke and through flow meters. The regulator or choke is used to regulate back pressure on the return line to control inflow from the well or fluid loss to the formation during downhole TFL operations.

5.4 TFL control console and instrumentation

Figure 6 shows a typical TFL instrumentation/control console. This instrumentation enables the monitoring of tool progress, tool operation and well fluid gain or loss. Instrumentation generally includes pressure gauges with strip chart recorders, pressure transducers located on the lubricator or manifold, and flow rate meters and volume totalizers on both the pump discharge and return lines. The instrumentation should be designed to withstand the vibrations and pressure surges that can occur. High-pressure screens or filters should be installed upstream of turbine flow meters to minimize damage to the meters by debris. Other types of meter may be used without the need for such filters.

In addition to control console instrumentation, pressure transducers with surface readout may be installed at the wellhead to assist in monitoring the tool location. Other special tool detection systems may be installed to monitor the location of a tool as it moves through the TFL system.

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