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Contents		•	Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
Foreword		v	Adjust space between Asian text and numbers
Introd	luction	i	
1	Scope	1	
2	Normative references	1	
3	Terms and definitions	1	
4	Properties of high viscosity liquids	3	
4.1	Viscosity	8	
4.2	Reynolds number and flow profile	8	
4.3	Density	4	
4.4	Effect of temperature on viscosity	4	
4.5	Examples of high viscosity liquids and behaviour	5	
4.6	Further considerations	6	
5	Metering systems	7	
5.1	General	7	
5.2	Installation	8	
5.3	Heating	9	
5.4	System start-up and filling	0	
6	Flowmeters1	1	
6.1	Differential pressure meters1	1	
6.2	Displacement meters1	2	
6.3	Turbine meters	3	
6.4	Coriolis mass flowmeters	۲	
6.5 tt	Ultrasonic meters1	6-3e2	
7	Meter proving1	8	
7.1	General1	8	
7.2	Pipe provers1	8	
7.3	Volumetric measures	9	
7.4	Gravimetric proving	D	
7.5	Master meter proving	D	
8	Volumetric corrections	D	
8.1	Standard volume	D	
8.2	Thermal expansion and temperature effects	1	
8.2.1	<u>Overview</u> 2	1	
8.2.2	Temperature effect on Coriolis meters2	2	
8.2.3	Thermal expansion for ultrasonic meters and differential pressure meters2	2	
8.2.4	Thermal expansion for displacement and turbine meters2	2	
<u>Biblio</u>	graphy2	4	

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iii

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introduction image: seque 1   image: seque 1 image:	Foreword iv	
2       Normative references       1         3       Terms and definitions       1         3       Definitions       3         4       Properties of high viscosity liquids       3         4       Properties of high viscosity liquids       3         4       Viscosity       3         4       Properties of high viscosity liquids       3         4       Viscosity       3         4       Second and mates       3         5       Representative convisional dominant       5         Figure 1       Representative considerations       6         6       Metering systems       7       1         7       Item Considerations       6       1         5       Metering systems       7       1         6       Properties of fight viscosity for a crude of the fight viscosity fight viscosity for a crude of the fight viscosity for a crude of the fight	Introduction v	
3       Terms and definitions -1         3.1       Definitions -1         3.2       Symbols and units -2         4.7       Properties chiph viscosityl liquids -3         4.1       Viscosity -3         4.2       Reproduct muther and flow profile -3         4.3       Density4         4.4       Effect of temperature on viscosity -4         4.5       Examples of high viscosity liquids and bohaviour -5         Figure 1       Reprosentative relationship of temperature to viscosity for a crude oil -6         4.6       Further considerations -6         5       Metering system -7         Installation -7       ITCAN Standards         Figure 2 - Schematic diagram of an installation -10       S://standards.iteh.ai/standards         5.4       General -7         Figure 2 - Schematic diagram of an installation -10       S://standards.iteh.ai/standards         5.4       Holine meters -11         6.1       Differential pressure meters -11         6.2       Diplecensent meters -12         6.3       Turbine meters -13         6.4       Corolic mass flowmeters -14         6.5       Utrassone meters -14         6.5       Utrassone meters -13         6.4       Corolic mass flowmeters -14	1 Scope 1	
21       Definitions       1         22       Symbols and units       2         4       Properties of high viscosity liquids       3         11       Viscosity       3         12       Reynolds number and flow profile       3         13       Density4       4         14       Effect of temperature on viscosity       4         15       Examples of high viscosity liquids and behaviour       5         Pigure 1       Representative relationship of temperature to viscosity for a crude oil       6         4.6       Further considerations       6         5       Metering systems       7       ITCAN Standards         5.1       General       2       Installation       9         5.4       System start up, and filling       10       Installation       9         5.4       System start up, and filling       10       Installation       9         6.4       Folowaters       11       Installation       9       Installation       9         6.4       System start up, and filling       10       Installation       9       Installation       9       Installation       9       Installation       9       Installation       9       Installation </th <th>2 Normative references 1</th> <th></th>	2 Normative references 1	
22       Symbols and units2         4       Properties of high viscosity liquids3         4.1       Viscosity	3 Terms and definitions 1	
<th>3.1 Definitions 1</th> <th></th>	3.1 Definitions 1	
4.1 Viscosity   4.2 Reynolds number and flow profile   4.3 Density4   4.4 Effect of temperature on viscosity   4.5 Examples of high viscosity liquids and behaviour   5.7 Figure 1   Representative relationship of temperature to viscosity for a crude oil   4.6 Further considerations   6 6   5 Metering systems   7 ITCeh Standards   5.1 General   7 ITCeh Standards   5.2 Installation   9 S.//standards.iteh.ati)   5.4 Boot meters   5.4 Notering on a installation   9 S.//standards.iteh.ati)   5.4 Heating   9 Document Preview   6.2 Displacement meters   11 ISOPPE 9200   6.2 Displacement meters   13 ISOPPE 9200   6.3 Ultrasonic meters   14 General   6.4 Croiving mass flow meters   15 Itrasonic meters   16 Itrasonic meters   17 Itrasonic meters   18 Itrasonic meters   19 Itrasonic meters   19 Itrasonic meters   10 Itrasonic meters   11 Itrasonic meters   12 Itrasonic meters   13 Itrasonic meters   14 Itrasonic meters   15 Itrasonic meters   16 Itrasonic meters   <	3.2 Symbols and units 2	
4.2 Reynolds number and flow profile   4.3 Density4   4.4 Effect of temperature on viscosity   4.5 Examples of high viscosity   4.5 Examples of high viscosity   Figure 1 Representative relationship of temperature to viscosity for a crude oil   6.6 Further considerations   6.7 Metering systems   7 ITech Standards   5.2 Institution   7 ITech Standards   5.3 Housing   6.4 System start up, and filling   6.3 Turbine meters   11 ISOPPE 9200   6.3 Turbine meters   12 Diplecoment meters   13 ISOPPE 9200   6.3 Turbine meters   14 Soppe 9   6.4 Coriolis mass flowmeters   15 Information   6.5 Ultraconic meters   16 Oriolis mass flowmeters   17 Isoppe Particle   6.5 Ultraconic meters   18 Isoppe Particle   6.4 Coriolis mass flowmeters   19 Isoppe Particle   7.4 General   7.5 Meter proving   7.5 Meter proving   7.5 Meter proving   7.5 Master meter proving   8.4 Volumetric measures   8.5 Volumetric measures   9.5 Master meter proving   9.5 Master meter proving   9.5 Master meter proving  <	4 Properties of high viscosity liquids 3	
4.3 Density4   4.4 Effect of temperature on viscosity — 4   4.5 Examples of high viscosity liquids and behaviour5   Figure 1 Representative relationship of temperature to viscosity for a crude oil _ 6   4.6 Further considerations6   5 Metering systems _ 7   6 ITEAN Standards   5.2 Installation _ 7   Figure 2 - Schematic diagram of an installation _ 10   5.3 Heating _ 9   5.4 System start up, and filling _ 10   6 Formeters _ 11   6.1 DOCUMPENT Preview   6.2 Diplement meters _ 11   6.3 Formeter _ 12   6.4 Coriolis mass flowmeters _ 14   6.5 Uhrasonic meters _ 15   7 Meter proving 17   7.1 Ceneral _ 72   7.2 Pipe provers _ 18   7.3 Volumetric measures _ 18   7.4 Gravimetric proving _ 19   7.5 Master meter proving _ 19   7.5 Master meter proving _ 19   7.5 Master meter proving _ 19   8.1 Standard volume _ 19   8.1 Standard volume _ 19   8.2 Thermal expansion and temperature effects _ 20	4.1 Viscosity 3	
4.4 Effect of temperature on viscosity   4.5 Examples of high viscosity liquids and behaviour   5 Figure 1   Representative relationship of temperature to viscosity for a crude oil   6.6 Further considerations   6 6   9 Metering systems   7 ITech Standards   5.2 Installation   7 Itech Standards   5.3 Heating   9 St./Standards.iteh.ai)   5.4 System start up, and filling   10 Itech Standards   6.4 Flowmeters   11 Itech Standards   6.3 Turbine meters   12 Itech Standards   6.4 Coriolis mass flowmeters   14 Coriolis mass flowmeters   15 Other term up   7 Itech Standards   7 Itech Standards   8 Sover term up   10 Itech Standards   11 Coriolis mass flowmeters   12 Itech Standards   7 Itech Standards   7 Itech Standards   8 Sover term up   10 Itech Standards   11 Coriolis mass flowmeters   12 Itech Standards   13 Volumetric measures   14 Sover term up   15 Itech Standards   16 Other term up   17 Itech Standards   18 Itech Standards   19 Itech Standards   19	4.2—Reynolds number and flow profile—3	
4.5 Examples of high viscosity liquids and behaviour 5 Figure 1 Representative relationship of temperature to viscosity for a crude oil 6 4.6 Further considerations 6 5 Metering systems 7 i Teh Standards 5.2 Installation 7 Figure 2 Schematic diagram of an installation 9 S://standards.iteh.ai) 5.3 Heating 9 5.4 System start up, and filling 10 6 Flowmeters 11 6.1 Differential pressure meters 11 6.2 Diplacement meters 12 6.3 Turbine meters 13 6.4 Coriolis mass flowmeters 14 6.5 Ultrasonic meters 15 7 Meter proving 17 7.1 Ceneral 17 7.2 Pipe provers 18 7.3 Volumetric measures 18 7.4 Gravimetric proving 19 8. Volumetric proving 19 8. Volumetric proving 19 8. Volumetric corrections 19 8. Volumetric corrections 19 8. Volumetric proving 19 8. Volumetric corrections 19 8. Volumetric proving 19 8. Volumetric corrections 19 8. Volumetric proving 19 8. Volumetric corrections 19 8. Volumetric proving 10 9. Volumetric provi	4.3 Density4	
Figure 1 Representative relationship of temperature to viscosity for a crude oil 6   4.6 Further considerations   5. Metering systems   7 ITeh Standards   5.2 Installation   7 Iteh Standards.iteh.ai   5.3 Heating   9 S.//standards.iteh.ai   5.4 System start up, and filling   10 Iteh Standards   6 Flowmeters   11 Iteh Standards   6.3 Heating   6.4 Flowmeters   11 Iteh Standards   6.5 Itersonic meters   12 Iteh Standards   6.5 Itersonic meters   13 Itersonic meters   6.5 Itersonic meters   14 Itersonic meters   6.5 Itersonic meters   15 Itersonic meters   7.1 Ceneral   17 Itersonic meters   18 Itersonic meters   19 Itersonic meters   19   8.1 Standard volume   9 Itersonic meters   19   8.1 Standard volume   8.2 Thermal expansion and temperature effects		
4.6 Further considerations 6   5 Metering systems 7   5.1 General 7   5.2 Installation 7   Figure 2 Schematic diagram of an installation 9   5.3 Heating 9   5.4 System start up, and filling 10   6 Flowmeters 11   6.1 Differential pressure meters 11   6.2 Displacement meters 12   6.3 Turbine meters 13   6.4 Coriolis mass flowmeters 14   6.5 Ultrasonic meters 15   7 Meter proving 17   7.1 Ceneral 17   7.2 Pipe provers 18   7.3 Volumetric measures 18   7.4 Gravimetric proving 19   7.5 Master meter proving 19   8.1 Volumetric corrections 19   8.1 Standard volume 19   8.2 Thermal expansion and temperature effects 20	4.5 Examples of high viscosity liquids and behaviour 5	
5 Metering systems 7   5.1 General 7   Figure 2 Schmatic diagram of an installation 9   5.2 Installation 7   Figure 2 Schmatic diagram of an installation 9   5.3 Heating 9   5.4 System start up, and filling 10   6 Flowmeters 11   6.1 Displacement meters 12   6.2 Turbine meters 13   6.3 Turbine meters 13   6.4 Corriolis mass flowmeters 14   6.5 Ultrasonic meters 15   7 Meter proving 17   7.4 General 17   7.2 Pipe provers 18   7.3 Volumetric measures 18   7.4 General 17   7.2 Pipe provers 18   7.3 Volumetric measures 18   7.4 General 17   7.2 Pipe provers 18   7.3 Volumetric corrections 19   8 Volumetric corrections 19   8.1 Standard volume 19   8.2 Thermal expansion and temperature offects 20	Figure 1 — Representative relationship of temperature to viscosity for a crude oil — 6	
5.1 General 7   Figure 2 Schematic diagram of an installation 9   5.3 Heating 9   5.4 System start up, and filling 10   6 Flowmeters 11   6.1 Differential pressure meters 11   6.2 Displacement meters 12   6.3 Turbine meters 13   6.4 Coriolis mass flowmeters 14   6.5 Ultrasonic meters 15   7 Meter proving 17   7.1 Ceneral 17   7.2 Pipe provers 18   7.4 Volumetric measures 18   7.5 Master meter proving 19   8 Volumetric corrections 19   8.1 Standard volume 19   8.2 Thermal expansion and temperature effects 20		
5.1 General 2 5.2 Installation 7 Figure 2 Schematic diagram of an installation 9 5.4 System start up, and filling 10 6 Flowmeters 11 6.1 Differential pressure meters 11 6.2 Displacement meters 12 6.3 Turbine meters 13 6.4 Coriolic mass flowmeters 14 6.5 Ultrasonic meters 15 7 Meter proving 17 7.1 General 17 7.2 Pipe provers 18 7.3 Volumetric measures 18 7.4 Gravimetric proving 19 7.5 Master meter proving 19 7.5 Master meter proving 19 8. Volumetric corrections 19 8.1 Standard volume 19 8.2 Thermal expansion and temperature effects 20		
5.3 Heating 9   5.4 System start up, and filling 10   6 Flowmeters 11   6.1 Differential pressure meters 11   6.2 Displacement meters 12   6.3 Turbine meters 13   6.4 Coriolis mass flowmeters 14   6.5 Ultrasonic meters 15   7 Meter proving 17   7.1 General 17   7.2 Pipe provers 18   7.3 Volumetric measures 18   7.4 Gravimetric proving 19   8.1 Standard volume 19   8.2 Thermal expansion and temperature effects 20	5.1 General 7	
5.3 Heating 9   5.4 System start up, and filling 10   6 Flowmeters 11   6.1 Differential pressure meters 11   6.2 Displacement meters 12   6.3 Turbine meters 13   6.4 Coriolis mass flowmeters 14   6.5 Ultrasonic meters 15   7 Meter proving 17   7.1 General 17   7.2 Pipe provers 18   7.3 Volumetric measures 18   7.4 Gravimetric proving 19   8.1 Standard volume 19   8.2 Thermal expansion and temperature effects 20	5.2 Installation 7 (https://standards.iteh.g	
5.4       System start up, and filling 10       DOCUMENT PREVIEW         6       Flowmeters 11       ISO/PRF 9200         6.2       Displacement meters 12       ISO/PRF 9200         6.3       Turbine meters 13       ISO/PRF 9200         6.4       Coriolis mass flowmeters 14       ISO/PRF 9200         6.5       Ultrasonic meters 15       ISO/PRF 9200         7       Meter proving 17         7.1       General 17         7.2       Pipe provers 18         7.3       Volumetric measures 18         7.4       Gravimetric proving 19         8       Volumetric corrections 19         8.1       Standard volume 19         8.2       Thermal expansion and temperature effects 20		
<ul> <li>Flowmeters 11</li> <li>6. Flowmeters 11</li> <li>6.2 Displacement meters 12</li> <li>6.3 Turbine meters 13</li> <li>6.4 Coriolis mass flowmeters 14</li> <li>6.5 Ultrasonic meters 15</li> <li>7 Meter proving 17</li> <li>7.1 Ceneral 17</li> <li>7.2 Pipe provers 18</li> <li>7.3 Volumetric measures 18</li> <li>7.4 Gravimetric proving 19</li> <li>8 Volumetric corrections 19</li> <li>8 Volumetric corrections 19</li> <li>8.1 Standard volume 19</li> <li>8.2 Thermal expansion and temperature effects 20</li> </ul>		
6.1Differential pressure meters11ISO/PRF 92006.2Displacement meters126.3Turbine meters136.4Coriolis mass flowmeters146.5Ultrasonic meters157Meter proving 177.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20		
6.2Displacement meters126.3Turbine meters136.4Coriolis mass flowmeters146.5Ultrasonic meters157Meter proving177.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20		
6.3Turbine meters136.4Coriolis mass flowmeters146.5Ultrasonic meters157Meter proving 177.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20	· ISU/PKF 9200	
6.3Turbine meters136.4Coriolis mass flowmeters146.5Ultrasonic meters157Meter proving 177.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving197.5Master meter proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20	https://standards.iteh.ai/catalog/standards/iso/95d8/.6td-eaeb-4ce3-9/.61-	
6.5Ultrasonic meters157Meter proving177.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving197.5Master meter proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20	<del>6.3 Turbine meters 13</del>	
7Meter proving 177.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving197.5Master meter proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20		
7.1General177.2Pipe provers187.3Volumetric measures187.4Gravimetric proving197.5Master meter proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20		
7.2Pipe provers187.3Volumetric measures187.4Gravimetric proving197.5Master meter proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20		
7.3       Volumetric measures 18         7.4       Gravimetric proving 19         7.5       Master meter proving 19         8       Volumetric corrections 19         8.1       Standard volume 19         8.2       Thermal expansion and temperature effects 20		
7.4Gravimetric proving197.5Master meter proving198Volumetric corrections198.1Standard volume198.2Thermal expansion and temperature effects20	• •	
7.5       Master meter proving 19         8       Volumetric corrections         9       8.1         Standard volume       19         8.2       Thermal expansion and temperature effects         20       Control of the standard temperature effects		
8       Volumetric corrections       19         8.1       Standard volume       19         8.2       Thermal expansion and temperature effects       20		
8.1     Standard volume     19       8.2     Thermal expansion and temperature effects     20		
8.2 Thermal expansion and temperature effects 20		
Bibliography 23	Bibliography 23	

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iv

#### 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see <a href="http://www.iso.org/directives">www.iso.org/directives</a>).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at <a href="https://www.iso.org/patents.lso">www.iso.org/patents.lso</a> shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 28, Petroleum and related products, fuels and lubricants from natural or synthetic sources, Subcommittee SC 2, Measurement of petroleum and related products<sub> $\pi_2</sub>$ </sub>

This second edition cancels and replaces the first edition ( $ISO_2200:1993$ ), which has been technically revised.

The main changes are as follows:

mass and volumetric metering is now covered;

- a description and definition of viscosity has been added along with a clarification of high viscosity and high temperature;
- the emphasis on positive displacement meters has been replaced by descriptions of other meter types including ultrasonic, Coriolis and differential pressure devices.

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 <u>www.iso.org/members.html</u>www.iso.org/members.html

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## Introduction

I

This document is intended to guide users in the design, installation, operation, and proving of flowmeters, and their auxiliary equipment, used in the dynamic metering of viscous liquids. It also provides guidance when elevated operating temperatures are used to reduce viscosity. The document applies to Newtonian, hydrocarbon and petroleum liquids. Extra consideration should be given when using other liquids and non-Newtonian liquids.

The objective of this document is to highlight <u>the</u> considerations <u>to be taken into account</u> when metering high viscosity liquids at normal and elevated temperatures<u>additional</u> in <u>addition</u> to the normal application of metering less viscous liquids at ambient temperatures.

- As the viscosity of a liquid increases, the resistance to flow increases. In a fluid transfer system, this generally means that the maximum flowrate achievable for any given conduit size is reduced to avoid excessive pressure loss. This generally results in lower velocities within the measurement system than would be found in lower viscosity applications. As most flow sensors and meters require a minimum velocity to provide reasonable resolution of measurement, the operational range of the flowmeter chosen can be reduced.
- Each flowmeter type and design has different limitations on the viscosity and flow range across which it operates at an acceptable accuracy. For higher viscosities and low velocities, it is probable that for many applications the flow regime is laminar rather than turbulent which again affects the performance of flowmeters.
- To provide efficient transport of the fluid within a pipe, viscous liquids are often heated to reduce the viscosity. Measuring systems and the associated flowmeters are therefore selected and operated to suit the chosen operating temperature, taking into account changes in temperature and viscosity from ambient conditions.
- The behaviour of the fluid should be considered carefully to <u>recogniserecognize</u> the potential for the liquid to solidify during idle periods and also to manage the potential for air, gas, solids, and wax, content from damaging or affecting the metering system.
- This document supplements-the guidance given in the guidance documents applicable to different flowmeter designs and proving methods in the relevant ISO standards referenced in the bibliography.

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Petroleum measurement systems <sub></sub> — Metering of viscous and high temperature liquids		Formatted: Right: 1.5 cm, Bottom: 1 cm, Gutter: 0 cm, Section start: New page, Width: 21 cm, Height: 29.7 cm, Header distance from edge: 1.27 cm, Footer distance from edge: 0.5 cm
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This document gives guidance whenfor measuring a quantity of primarily viscous hydrocarbon liquid i measured using flowmeters at ambient or elevated operating temperatures.		Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
The objective of this document is to highlight considerations when metering high viscosity liquids at norma and elevated temperatures from the normal application of metering less viscous liquids at ambien temperature.		Formatted: Indent: First line: 0 cm, Right: 0 cm, Space Before: 0 pt, Line spacing: single, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
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3 Terms and definitions		
For the purposes of this document, the following terms and definitions apply.		
ISOand IECmaintain terminology databases for use in standardization at the following addresses:	<b>ai</b>	
— ——ISO-Online browsing platform: available at <a href="https://www.iso.org/obphttps://www.iso.org/obp">https://www.iso.org/obp</a> IEC Electronedic available at <a href="https://www.iso.org/obp">https://www.iso.org/obp</a>	•	<b>Formatted:</b> Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
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3.1 Definitions		Adjust space between Asian text and numbers
3.1.1 <u>ISO/PRF 9200</u> densityhttps://standards.iteh.ai/catalog/standards/iso/95d826fd-eaeb-4ce3-976 mass in a given volume	-3e7	<b>Formatted:</b> Example, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
3. <del>1.</del> 2 performance indicator		Formatted: Adjust space between Latin and Asian text,
derived value which relates the meter output to the quantity measured and can be used to indicate th	e / /	Adjust space between Asian text and numbers
performance of the meter	[]]	Formatted: Regular Formatted: Don't keep with next, Adjust space
-EXAMPLEError, meter factor, K-factor, and discharge coefficient.		between Latin and Asian text, Adjust space between Asian text and numbers
<b>3.1.3</b> <b>pipe prover</b> <b>displacement prover</b> device where <u>athe</u> volume of <u>a</u> fluid is displaced from <u>athe</u> calibrated length of <u>a</u> pipe and used to provide calibration references for flowmature	a	Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
calibration reference for flowmeters		Formatted: Font: 10 pt
3.14	•	Formatted: Font: 10 pt
<b>pour point</b> lowest temperature at which a liquid product loses its flow characteristics and, under specified conditions	, / //	Formatted: Font: Not Bold
ceases to flow		Formatted: FooterPageRomanNumber, Space After: 0 pt, Line spacing: single
Note-1-to-entry:-The temperature at which a liquid ceases to flow is based on a standard test.	•    /	Formatted: Font: 11 pt
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<u>ISO/PRF 9200:2024(en)</u>	Formatted: HeaderCentered
	Formatted: Font: Bold
3.1.5 Reynolds number dimensionless number expressing the ratio between the inertia forces and viscous forces within a flowing fluid	Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
iote-1-to entry:-The Reynolds number can provide an indication of the flow profile within a pipe. Generally, numbers elow 2-000 indicate a laminar flow, while a number higher than 5-000 indicates a turbulent flow. iote-2-to entry:-The Reynolds number and performance indicator for some flowmeters provides a single relationship which accounts for variations in viscosity as well as flowrate.	<b>Formatted:</b> Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
3.1.6 viscosity measure of resistance to flow	Formatted: Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
3. <del>1.</del> 7 dynamic viscosity viscosity dynamic	
viscosity absolute	Formatted: Regular, Font: Bold
ratio of shear stress to shear rate within the fluid, hence the force needed to overcome internal friction	Formatted: Font: Bold
	Formatted: Regular
Note-1-to-entry:-The unit of absolute viscosity is Pascal second (Pa s). The unit of centiPoisecentipoise (cP) is commonly used in practice. 1cP-==(1*×10 <sup>-3</sup> Pa s). 3.1.8	<b>Formatted:</b> Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
kinematic viscosity viscosity kinematic	Formatted: Adjust space between Latin and Asian text,
ratio of <i>dynamic viscosity</i> <del>(3.1.7)</del> to density, <del>(3.1.1)</del> (3.1)	Adjust space between Asian text and numbers
Document Preview	Formatted: Regular
Note_1-to_entry:-The unit of kinematic viscosity is metre square per second ( $m^2 s^{-1}$ ). The unit <u>centiStoke_centistoke</u> (cSt)* is commonly used in practice. $1cSt = (10^{-6} m^2 s^{-1}) = (1 mm^2 s^{-1})$ . The unit $4 mm^2 s^{-1}$ is used throughout this document when giving examples of fluid viscosity.	Formatted: Space After: 12 pt, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
<u>ISO/PRF 9200</u>	Formatted: Font: Not Italic
<b>3.1.9</b> https://standards.iteh.ai/catalog/standards/iso/95d826fd-eaeb-4ce3-9761* e. performance indicator derived value which may be used to indicate the performance of the meter	<b>Formatted:</b> Adjust space between Latin and Asian text, Adjust space between Asian text and numbers, Tab stops: Not at 0.7 cm + 1.4 cm + 2.1 cm + 2.8 cm + 3.5 cm + 4.2 cm + 4.9 cm + 5.6 cm + 6.3 cm + 7 cm
Note 1 to entry: Examples of performance indicators are errorEXAMPLE Error, K-factor, meter factor or discharge coefficient.	Formatted: TermNum, Adjust space between Latin and Asian text, Adjust space between Asian text and numbers
3.1.10 volumetric measure measure used to provide an accurate measurement of volume to provide a reference for other volume measuring devices	
0.4.44	Formatted: Regular
3.4.11 wax point	Formatted: Regular
cloud point	Formatted: Term(s)
wax precipitation point	Formatted: Space After: 12 pt
temperature at which wax precipitates from a hydrocarbon liquid	Formatted: Font: 10 pt
	Formatted: Font: 10 pt
3.2-Symbols and units	Formatted: FooterPageRomanNumber, Space After: 0
For the purposes of this document, the symbols used are given within the text	pt, Line spacing: single
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<u>ISO/PRF 9200:2024(en)</u>	•	Formatted: Font: Bold	
		Formatted: HeaderCentered	
4 Properties of high viscosity liquids	4	Formatted: Adjust space between Latin and Asian tex Adjust space between Asian text and numbers	αt,
<b>4.1 Viscosity</b> In this document a viscous liquid is any liquid that requires special treatment or equipment in its handling o		Formatted: Adjust space between Latin and Asian tex Adjust space between Asian text and numbers, Tab stops: Not at 0.71 cm	αt,
storage because of its resistance to flow at either ambient or operating temperature. The liquid is assumed to be Newtonian. If the fluid is non-Newtonian, additional influences on metering should be considered.	)	Formatted: Adjust space between Latin and Asian tex Adjust space between Asian text and numbers	αt,
Viscosity is typically expressed as being either dynamic or kinematic.			
Dynamic viscosity ( $\mu$ ) and kinematic viscosity ( $v$ ) are related through density ( $\rho$ ) by Formula (1). Formula (1)	•	Formatted: Indent: Left: 0.71 cm	
$\mu = \nu \rho \tag{1}$		Formatted: Table body (+), Adjust space between Lat and Asian text, Adjust space between Asian text and	in
where	• /	numbers	
$\mu_{\rm L}$ is the dynamic viscosity. expressed in Pascal seconds (Pa s);	$\checkmark$	Formatted: Font: Not Italic	
$\rho_{\rm A}$ is the density, expressed in kilograms per cubic metre (kg m-3);	•	Formatted Table	
v is the kinematic viscosity, expressed in metre square per second (m <sup>2</sup> s <sup>1</sup> ).	•	Formatted: Font. Not italic Formatted: Table body (+), Adjust space between Lat	tin
iTah Standarda		and Asian text, Adjust space between Asian text and numbers	
When applying this conversion, or any other use of a viscosity relationship, <u>consistent and</u> matching unit should be used <u>and, to avoid error, the use of</u> . <u>Using</u> the relevant SI unit is recommended as given i Formula (1) helps to avoid error.		Formatted: Table body (+), Adjust space between Lat and Asian text, Adjust space between Asian text and numbers	in
4.2 Reynolds number and flow profile		Formatted: Font: Not Italic	
De course and Decarious		Formatted	
The Reynolds number provides a scale to represent the turbulence within a flowing fluid, hence providing guide to the velocity profile within a pipe. <u>The Reynolds number is calculated from Formula (2)</u> . Formula (2)		Formatted	
		Formatted	
$\frac{Re}{\mu} = \frac{VD\rho}{\nu} \frac{VD\rho}{\nu} Re = \frac{VD\rho}{\mu} = \frac{VD}{\nu} $ $\frac{ISO/PRF 9200}{\nu} $ (2)	/	Formatted	
https://standards.iteh.ai/catalog/standards/iso/95d826fd-eaeb-4ce3-976	-3/07	Formatted Table	
where	•	Formatted: Font: Not Italic	_
		Formatted	(
D		Formatted: Font: Not Italic	_
<i>V</i> is the mean pipe velocity, expressed in metre square per second (mm² s=1);	*//	Formatted	
$\rho_{\star}$ is the density -(, expressed in kg m <sup>3</sup> );	•	Formatted: Font: Not Italic	_
$\mu_{\rm a}$ is the dynamic viscosity <del>(, expressed in</del> Pa s <del>);</del>	-	Formatted: Font: Not Italic	
$v_{\rm is}$ is the kinematic viscosity <del>(_expressed in</del> m <sup>2</sup> s <sup>-1</sup> <del>).</del>	•	Formatted: Font: Not Italic	
When calculating the Reynolds number, it is important to ensure the units used are consistent-and the use of	•	Formatted	_
Using the relevant SI unit is recommended.as given in Formula (2) helps to avoid error.		Formatted	<u></u>
Generally, laminar flow is present at Reynolds numbers below <del>2 0002 000</del> and turbulent flow at Reynold		Formatted	
numbers above $\frac{50005000}{5000}$ . Between $\frac{20002000}{2000}$ and $\frac{50005000}{5000}$ , a transitional condition is found wher		Formatted: Font: 10 pt	
either laminar or turbulent or a changing flow condition exists. Within the transitional range, the condition	. ,	Formatted: Font: 10 pt	
can switch between regimes. These values are indicative and the Reynolds numbers at which the transition between laminar and turbulent flow occurs is variable and depends on of a variety of factors. These include		Formatted: Font: Not Bold	_
but are not limited to, pipe configuration, pipe roughness, temperature, orientation and vibration. Typically		Formatted	_
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