

Recommended Practice for Training and Qualification of Drilling Fluid Technologists

Upstream Segment

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FOREWORD

A professional discipline of Petroleum Engineer is divided into sub-disciplines in which technical expertise is required. One of the sub-disciplines deals with fluids that are essential to the operation of many exploration and production petroleum and natural gas operations and include:

- Drilling fluids;
- Completion fluids;
- Solids control;
- Cementing;
- Stimulation.

These technologies are similar in that they combine the need for both engineering and chemistry knowledge and skills. These specialized operations may not be covered in depth by colleges and universities that have petroleum engineering curricula. The knowledge is gained by on-the-job training. In addition, these operations do not necessarily require an engineering or scientific degree, or even an academic degree at all. By a combination of formal training and practical experience, and in some cases the use of intuitive and common sense skills, individuals have become recognized experts in developing and applying these technologies in field applications.

As there is not a clear definition of minimum competency for the drilling fluids technologist professions, API Committee 3, Subcommittee 13, Drilling and Completions Fluid, formulated an objective to establish criteria for minimum competency for field drilling fluids technologists. This was done by developing a two dimensional matrix of breadth and depth statements to be met by a technologist immediately after successfully completing a basic drilling fluids training course. The breadth-depth format is similar to current efforts by the National Council of Examiners for Engineering and Surveyors (NCEES) to improve the statistical validity of its certification exams. This standard is not intended to establish certification procedures for drilling fluids personnel, but is to be used for general guidance in evaluating training processes and evaluating the professional acceptability of drilling fluid technologists.

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Recommended Practice for Training and Qualification of Drilling Fluid Technologists

1 Scope

This standard is a written summary of basic training and knowledge that an employee or contractor shall possess to be identified as a drilling fluids technologist. Levels of understanding have been generally outlined, but not totally defined.

2 References

API

Spec 13A	<i>Drilling Fluid Materials</i>
RP 13B-1	<i>Standard Procedure for Field Testing Water-Based Drilling Fluids</i>
RP 13B-2	<i>Standard Procedure for Field Testing Oil-Based Drilling Fluids</i>

ISO

13500	<i>Petroleum and natural gas industries—Drilling fluid materials—Specifications and tests</i>
10414-1	<i>Petroleum and natural gas industries—Field Testing of Drilling Fluids—Part 1: Water-based fluids</i>
10414-2	<i>Petroleum and natural gas industries—Field Testing of Drilling Fluids—Part 2: Oil-based fluids</i>

3 Terms, Definitions and Abbreviations

3.1 TERMS AND DEFINITIONS

3.1.1 breadth: The basic knowledge common to all areas of drilling fluids technology needed by all drilling fluids technologists to demonstrate minimum competency.

3.1.2 depth: The knowledge acquired by all drilling fluids technologists following 4 – 6 years of practical experience.

3.1.3 drilling fluids engineer: A drilling fluids technologist with an engineering degree from an accredited university.

3.1.4 drilling fluids technician: An individual skilled in the art of testing drilling fluids in the field or the laboratory.

3.1.5 drilling fluids technologist: Individual with specialized knowledge of the application of drilling fluids during the drilling operation.

3.1.6 senior drilling fluids technologist/engineer: A drilling fluid technologist or engineer who by training and experience has advanced knowledge of drilling fluids, drilling fluid chemistry, and their varied applications.

3.2 ABBREVIATION

API	American Petroleum Institute
HTHP	High temperature, high pressure
MBT	Methylene blue test
PV	Plastic viscosity in cP (1 cP = 1 mPa*s)
YP	Yield point in Pa

4 Principle

This document is a recommended practice (RP) and seeks to formalize the specific knowledge base, professional skills, and application skills needed to ensure the competency and professionalism of individuals working in the drilling fluids industry. Drilling fluids technologists should use this RP as an outline to self-determine any gaps in learning and seek to improve their skills. A company contracting the service of a drilling fluids technologist should use this recommended practice as a checklist of knowledge that a technologist should be able to demonstrate proficiency in applying.

5 Procedure

5.1 ORIGINS OF DISCIPLINES AND SUB-DISCIPLINES

The drilling fluids disciplines and sub-disciplines were developed from a review of the typical curricula followed by drilling fluids service companies in their basic mud school. The topics as listed in Appendix A were used as a framework for developing the guidelines that form the normative portion of this standard. Each sub-discipline was divided into appropriate tasks and those tasks were assigned breadth of knowledge statements needed to obtain minimum competency. The drilling fluid technologist discipline is broken into six sub-disciplines and each sub-discipline is described by tasks and specific skills to demonstrate proficiency and knowledge in that task. For ease of reading, the tasks and skill set are placed in a table format.

5.2 BASIC INDUSTRY STANDARDS USED FOR GENERIC INFORMATION

API Spec 13A and ISO 13500, *Specifications for Drilling Fluid Materials*, provide specifications for drilling fluid material. Two documents cover the field testing procedures for tests included on the drilling mud report form. These are API RP 13B-1 or ISO 10414-1, *Standard Procedure for Field Testing of Water-based Drilling Fluids*, and API RP 13B-2 or ISO 10414, *Standard Procedure for Field Testing of Oil-based Drilling Fluids*.

5.3 SUB-DISCIPLINE—GENERAL INFORMATION

Table 1—General Information of Tasks and Skills

TASK	SKILLS
Rotary drilling operations	<ul style="list-style-type: none"> Name the parts of a rotary drilling rig. Describe the components of a rotary drilling circulating system. Describe the rotary drilling process. Describe the functions of rig crew and supervisory personnel.
Drilling fluid functions	<ul style="list-style-type: none"> List the functions of drilling fluids.
Drilling fluids properties	<ul style="list-style-type: none"> List the commonly used drilling fluid properties. Match each mud property to related function.
Drilling fluids testing	<ul style="list-style-type: none"> List each commonly used drilling fluid test and its units. Relate each drilling fluid test to the appropriate property or function. Perform the recommended API drilling fluids tests according to the appropriate API RP satisfactorily. Completely fill out the API Mud Report Form for water- and oil-based muds.
Drilling fluids composition	<ul style="list-style-type: none"> List the types of drilling fluids by base fluids. List the components of typical drilling fluid systems. Identify the function of each component in a drilling fluid system. Match drilling fluid systems to specific applications.

5.4 SUB-DISCIPLINE—DRILLING FLUID CHEMISTRY

Table 2—Drilling Fluid Chemistry Tasks and Skills

TASK	SKILLS
Water and base fluid chemistry	<ul style="list-style-type: none"> Identify chemical properties and relate them to a drilling fluids performance. Describe the API tests for chemical properties. List the basic physical properties of common base fluids specified for drilling fluid use.
Weight material	<ul style="list-style-type: none"> List commonly used weight materials. Give chemical and physical behavior of each weight material. List API specifications for weight materials.
Clay chemistry	<ul style="list-style-type: none"> List types of clays used in drilling fluids. Describe chemical and physical behavior of each clay. Identify the commonly occurring clay association states found in drilling fluids.
Filtrate chemistry	<ul style="list-style-type: none"> Define alkalinity, salinity and hardness. List the typical ions associated with each of these types of filtrate components. Relate each filtrate component to its possible effects on drilling fluid performance. Calculate the quantitative amounts of each component from filtrate titration numbers.
Contamination	<ul style="list-style-type: none"> List the common drilling fluid contaminants. Identify the effects on various types of drilling fluid systems of each contaminant Identify the test indicators of each type of contaminant. List commonly recommended treatments for each type of contamination to remove the contaminant and restore the mud's properties.
Polymers	<ul style="list-style-type: none"> List types and functions of polymers used in drilling fluids. List specific polymers (generic names) that fall into the types and classifications. Describe the limitations of each generic polymer type, related to its function in a drilling fluid.
Brines	<ul style="list-style-type: none"> Identify the chemical compositions of brines used in drilling completion, and workover fluids. Demonstrate an ability to measure brine densities using hydrometers. Describe the terms TCT and PCT. List the chemical and physical properties of each brine. Relate the compositions and properties of brines to specific applications. Identify typical contaminants and their effects in completion brines.

5.5 SUB-DISCIPLINE—DRILLING FLUID ENGINEERING

Table 3—Drilling Fluid Engineering Tasks and Skills

TASK	SKILL
Wellbore geometry and casing	<ul style="list-style-type: none"> Describe the relationships among pore pressure, depth, and hole size, with respect to casing setting decisions. Calculate hole volumes, flow rates, and circulating times. Draw a schematic of a wellbore, properly labeled.
Drilling fluids circulating systems	<ul style="list-style-type: none"> Calculate total volumes, volume/depth, and retention time. Diagram a rig tank setup for proper mixing, settling, and flow. Describe the functioning of a rig mud pump. Calculate pump output.
Rheology	<ul style="list-style-type: none"> Use a viscometer to measure the shear stresses at various shear rates. Calculate the commonly measured rheological properties. Describe the commonly used drilling fluid, rheological mathematical models. Plot viscosity versus shear rate and determine effective viscosities. Describe the use and limitations of the API Funnel Viscosity. Describe how and which viscosity measurements relate to hole cleaning.
Hydraulics	<ul style="list-style-type: none"> Calculate pressure drops for each annular section. Calculate the Equivalent Circulating Density (ECD). Calculate the cuttings transport efficiency. Calculate the relationship of drilling fluid viscosity to surge and swab pressures, solids suspension, and weight material sag. Define each of these terms.
Solids analysis	<ul style="list-style-type: none"> Use the API retort to measure the water, oil and solids content in a drilling fluid. Describe the causes of solids buildup. Measure the MBT and calculate the equivalent concentration of bentonite. Calculate the low gravity and high gravity solids in fresh water, salt water, oil-based, and synthetic-based fluid. Describe the relationship between solids content in a drilling fluid and the API Plastic Viscosity and Yield Point. Calculate the drilled solids to bentonite ratio and describe its significance. Calculate a material balance verification of the primary solids analysis calculations.
Solids control	<ul style="list-style-type: none"> Describe why adequate solids control on the rig is important. List the size classification of solids in a drilling fluid. List the typical types of drilled solids. Explain the importance of particle size distribution and solids surface area. Explain the economic importance/impact of dilution in drilling fluids. List the types of solids control equipment normally found on a drilling rig. Draw a diagram placing each type of solids control equipment in proper sequence for both an unweighted mud and a weighted mud (water- and oil-based) and in its proper place in the rig pit system to assure sequential processing. Describe the concept of full flow processing. Describe the importance of shale shakers and screen sizes. Describe the relationship between screen mesh designation, wire diameter, screen opening dimensions on cut point, and screen life.
Fluid Loss Control	<ul style="list-style-type: none"> Describe drilling fluid loss and its effect on drilling fluids and the drilling operation. Use the API low pressure and HTHP filter presses to obtain filtrate data. Plot a filtrate versus square root of time fluid loss graph. Describe spurt loss and constant rate filtration. Explain the concept of permeability and porosity. Describe the difference between static and dynamic filtration. List the factors that control filtration in drilling fluids.
Lost circulation	<ul style="list-style-type: none"> Describe the causes and types of lost circulation. Describe treatments for each type of lost circulation.
Stuck pipe	<ul style="list-style-type: none"> Describe how the fluid properties of mud weight and viscosity effect lost circulation. Describe the causes and types of stuck pipe.

Table 3—Drilling Fluid Engineering Tasks and Skills

TASK	SKILL
	<ul style="list-style-type: none"> Describe the proper treatments for each type of stuck pipe. Describe how mud properties of mud weight, viscosity, and fluid loss relate to getting pipe stuck and releasing stuck pipe. Describe how to mix and spot a stuck pipe pill. Calculate a spotting pill volume to cover a given length of drill pipe.
Well control	<ul style="list-style-type: none"> Describe the causes of wellbore instability. Describe the difference between water-based and non-aqueous muds in reference to wellbore stability. Describe how the mud weight relates to wellbore stability.
Lubricity	<ul style="list-style-type: none"> Understand how torque and drag are measure on a drilling rig rig and how mud performance relates to torque and drag. Describe how hole cleaning and wellbore instability effect torque and drag in the well. List several different types of chemicals used to affect mud lubricity.

5.6 SUB-DISCIPLINE—NON-AQUEOUS DRILLING FLUIDS

Table 4—Non-aqueous Drilling Fluids Tasks and Skills

TASK	SKILL
Fundamentals	<ul style="list-style-type: none"> Describe a non-aqueous fluid (NAF) and explain how it differs from a water-based fluid. List the advantages and disadvantages of NAF. Describe an “invert emulsion”. Explain the “activity” concept of wellbore stability as it relates to NAF.
Formulations	<ul style="list-style-type: none"> List the base fluids commonly used to prepare NAF drilling fluids. List the physical properties measured for a base fluid. List the typical components of a NAF and the function of each component. Describe why aromatic content of a base fluid is important. Describe why the pour point of a base fluid is important. Describe how to make a “good” emulsion. Describe why salts are added to the aqueous phase. Describe why all solids in a NAF must be “oil wet”. Describe the effects of water wet barite in a NAF.
Test procedures	<ul style="list-style-type: none"> Use the API retort to measure the liquid and solids fraction in the fluid. Calculate the solids, oil and water content. Calculate “oil/water ratio”. Calculate the salt content, alkalinity, and excess lime content of the fluid. Use the API Emulsion Stability Meter to determine the electrical stability of a NAF.
Handling and maintenance	<ul style="list-style-type: none"> Describe the special handling needed for NAF. List the modifications and special precautions needed on the rig to handle NAFs, including personal protective equipment. Describe the special environmental considerations needed when drilling with NAFs.
Displacements	<ul style="list-style-type: none"> Write a procedure for displacing NAFs into or out of either a cased hole or into an open hole.

5.7 SUB-DISCIPLINE—FLUID FORMULATIONS AND ADDITIVES

Table 5—Fluid Formulations and Additives Tasks and Skills

TASK	SKILL
Systems	<ul style="list-style-type: none"> Describe the uses, advantages, and disadvantages of simple systems such as spud muds, clear-water fluids, and native mud systems. Describe the uses, advantages, and disadvantage of chemically treated water-based drilling fluids. Describe the uses, advantages, and disadvantage of low solids, non-dispersed drilling fluids. Describe the uses, advantages, and disadvantages of polymer systems. Describe the uses, advantages and disadvantages of drill-in fluids. Describe the uses, advantages and disadvantages of NAFs.
Additives	<ul style="list-style-type: none"> List the typical additives for each of the above drilling fluids systems along with their advantages and disadvantages. Demonstrate a proficiency for pilot testing drilling fluid additives.

5.8 SUB-DISCIPLINE—LOGISTICS AND MAINTENANCE

Table 6—Logistics and Maintenance Tasks and Skills

TASK	SKILL
Rigsite fluid management	<ul style="list-style-type: none"> Maintain a product inventory on the rig. Calculate the fluid costs. Write an end-of-well report. Describe special precautions needed to protect the quality of drilling fluid additives when stored on a drilling rig, both onshore and offshore. Perform a material balance of the active mud system. Describe the proper handling of drilling cuttings and excess mud.
Health, safety and environment	<ul style="list-style-type: none"> Describe the purpose of a material safety data sheet. List the hazardous chemicals commonly used in drilling fluids. Describe how to treat a caustic soda burn. Describe the personal protective equipment needed for both water-based and non-aqueous fluids. Write a procedure for handling spills around the rig, both onshore and offshore.

APPENDIX A

A.1 Principle

New employees in the drilling fluids industry are generally trained by the employer through a multi-discipline “school” or “seminar” which covers common drilling fluid types, formulation, handling, disposal and product safety as well as company specific issues of inventory, ordering, communications, and company specific systems and applications.

A.2 Typical Basic Mud School Curriculum

A.2.1 DRILLING FLUIDS TECHNOLOGY

- A.2.1.1 Introduction to rotary drilling
- A.2.1.2 Purpose and functions of drilling fluids
- A.2.1.3 Drilling fluids properties
- A.2.1.4 Drilling fluids testing
- A.2.1.5 Drilling fluids composition

A.2.2 DRILLING FLUIDS CHEMISTRY

- A.2.2.1 Water, base fluid, and oil chemistry
- A.2.2.2 Weight materials
- A.2.2.3 Clay chemistry
- A.2.2.4 Filtrate chemistry
- A.2.2.5 Contamination
- A.2.2.6 Polymer
- A.2.2.7 Brines

A.2.3 DRILLING FLUIDS ENGINEERING

- A.2.3.1 Wellbore geometry and casing
- A.2.3.2 Drilling rigs and mud tanks
- A.2.3.3 Rheology
- A.2.3.4 Hydraulics
- A.2.3.5 Solids analysis
- A.2.3.6 Solids control

- A.2.3.7 Fluid loss control

- A.2.3.8 Lost circulation

- A.2.3.9 Stuck pipe

- A.2.3.10 Borehole stability

- A.2.3.11 Well control

- A.2.3.12 Lubricity

A.2.4 NON-AQUEOUS MUD TECHNOLOGY

- A.2.4.1 Fundamentals

- A.2.4.2 Formulations

- A.2.4.3 Testing procedures

- A.2.4.4 Shale drilling

- A.2.4.5 Handling and maintenance

- A.2.4.6 Displacements

A.2.5 FLUID FORMULATIONS AND ADDITIVES

- A.2.5.1 Simple systems

- A.2.5.2 Chemical muds

- A.2.5.3 Low-solids, non-dispersed

- A.2.5.4 Polymer systems

- A.2.5.5 Brine systems

- A.2.5.6 Drill-in fluids

- A.2.5.7 Oil and Non-aqueous muds

- A.2.5.8 Additives

A.2.6 LOGISTICS AND MUD MAINTENANCE

- A.2.6.1 Pilot testing

- A.2.6.2 Inventories

- A.2.6.3 Cost control

- A.2.6.4 Reporting and communications

- A.2.6.5 Disposal and waste management

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