Appendix A

Pump System Certified – Level 1
Body of Knowledge

This Appendix provides the body of knowledge upon which the Pump System Certified – Level 1 examination for certification is based. The examination will cover the following knowledge areas:

A-1 Introduction to Pumps (10%)

a) Summarize basic pump function and purpose of major pump components
b) Identify pump terminology, descriptions, and acronyms
c) Identify a bare pump along with the basic components of a pump with driver and an extended pump product
d) Identify common pump types including overhung impeller (OH), between bearing (BB), vertically suspended (VS), rotary and reciprocating pump types
e) Explain the basic operating theory of a RD pump
f) Explain the basic operating theory of a PD pump
g) List general application considerations for RD pumps
h) List general application considerations for PD pumps
i) Compare and contrast the general shape and general characteristics of RD and PD performance curves
j) Compare the different natures of flow generated by rotary and reciprocating pumps

A-2 Pump Performance Curves and Power Consumption (15%)

a) Identify and describe types of performance curves that may appear on a pump performance graph
b) Identify and explain basis of and information plotted or indicated on the pump curve
c) Define and calculate pump output power, pump input power, and electrical input power (the latter both with and without a Variable Speed Drive [VSD])
d) Convert between horsepower (hp) to kilowatts (kW)
e) Calculate flow, head, and power changes per the affinity rules

A-3 Pump Systems (15%)

a) Explain the purpose and function of pumps and pump systems
b) Define the terms fluid and liquid
c) Describe fluid properties that affect pump and system performance
d) Identify types of horizontal and vertical pump systems
e) Identify boundaries for determining the system curve
f) Explain purposes of system types
g) Define pressure and head – and their relationship
h) Cite and define all types of pressure
i) Identify the component parts of pump total head
j) Use charts to determine friction loss through pipes, valves, and fittings
k) Define the system curve
l) Understand why the system curve determines the operating head and flow rate
m) Explain characteristics of flat and steep system curves
n) Explain cavitation and how it affects a pump system
o) Calculate friction loss through pipes, valves, fittings via simple calculations for pipe or fittings given variables
p) Define Net Positive Suction Head Required (NPSHR), Net Positive Suction Head – 3 (NPSH3), Net Positive Suction Head Available (NPSHA), Net Positive Inlet Pressure Required (NPIPR), Net Positive Inlet Pressure Available (NPIPA), and Net Positive Suction Head (NPSH) margin
q) Describe system factors that affect the pump allowable operating region (AOR)

A-4 Rotodynamic Pump Designs and Types (10%)

a) Identify the three major categories of rotodynamic pumps (radial flow, mixed flow, and axial flow)
b) Calculate specific speed
c) Identify common components in the construction of rotodynamic pumps
d) Compare and contrast characteristics of the performance curves based on specific speed
e) Identify the shapes of the four major types of impellers (open, semi-open, enclosed, and double inlet)
f) Describe and explain the purpose of impeller balancing
g) Identify the various types of pump casings and discharge collectors
h) Identify and describe the characteristics of overhung (OH), between bearing (BB), vertically suspended (VS) pumps
i) Compare and contrast pumps that are flexibly coupled, close coupled and rigidly coupled
j) Identify deep set and short set vertical turbine pumps
k) Identify open lineshaft pumps and enclosed lineshaft pumps
l) Relate categories of RD pumps and their associated specific speeds
m) Identify sealless pumps (canned motor pump and magnetic drive pump)
n) Describe methods to control leakage across the impeller from high pressure to low pressure within the pump and effects on pump performance
o) Identify the pump preferred operating region (POR)
p) Describe pump design considerations that affect the allowable operating region (AOR)

A-5 Positive Displacement Pump Designs and Types (5%)

a) Explain how positive displacement pumps generate flow
b) Identify and describe the two positive displacement types – rotary and reciprocating
c) Describe the component construction and performance characteristics of rotary pumps
d) Describe the component construction and performance characteristics of reciprocating pumps
e) List types of rotary and reciprocating pumps
f) Cite application considerations supporting use of positive displacement pumps
g) Identify common components in the construction of positive displacement pumps
h) Explain relationship of flow rate to positive displacement pump speed
i) Explain why positive displacement total differential pressure is not related to speed and what dictates the maximum total differential pressure
j) Explain the importance of pressure relief valves for use with PDs
k) Calculate output power and input power by a positive displacement pump

A-6 Pump Components and Accessories (5%)

a) Compare and contrast basic mechanical seals and packing types
b) Explain the purposes of packing and seal glands
c) Identify lubrication and cooling methods for packing
d) Identify and describe mechanical seal plans – and support systems when applicable
e) Describe bearings and bushings used in pumps
f) Explain why bearing seals are used
g) List bearing lubrication methods and lubricants
h) Describe the types of static sealing
i) Explain the purpose of couplings, drive shafts, and gears between the driver and the pump
j) Explain data on a typical nameplate for the pump

A-7 Drivers and Drives (5%)

a) Compare and contrast pump drivers, including electric and non-electric types.
b) Describe construction and features for electric motor types
c) Describe motor frame sizes and standard dimensions
d) Explain relevant driver standards
e) List motor electrical parameters (poles, frequency, phase, voltage, etc.)
f) List types of data found on technical data sheet, characteristic curve, and nameplate
g) List motor enclosures and their suitable uses
h) List driver starting methods
i) Describe features and characteristics of Variable Frequency Drives (VFDs)
j) Describe VFD installation and environment considerations including temperature and altitude

A-8 System Design Considerations (5%)

a) Identify and explain purpose of major pump system components
b) Describe examples of end use equipment
c) Identify purpose of applicable standards
d) Identify common pump industry symbols, icons, subscripts, and abbreviations

A-9 Varying the Pump Operating Point (6%)

a) Explain design point on a pump curve, and why alternate operating points may be required
b) Apply affinity rules based on impeller diameter and speed changes
c) Cite methods to modify pump performance or control the flow or pressure: On/Off, throttling, bypass, variable speed, and impeller trim
d) Explain implications of various curve shapes, including flat and steep
e) Explain parallel pumping and how it impacts flow and head
f) Explain series pumping and how it impacts flow and head

A-10 Pump Selection and Specification (5%)

a) Determine most applicable pump types for common applications
b) List sizing/selection - application data requirements
c) Describe liquid characteristics and the effect on pump selection
d) Select appropriate pump based on hydraulic selection criteria provided (i.e. flow, head, and NPSHA)
e) Discuss common materials of construction for wet end parts and the factors affecting their selection

A-11 Testing (5%)

a) Describe performance test – flow, head, power
b) Describe pump efficiency, bowl efficiency, and overall efficiency
c) Explain what differentiates a certified curve from other performance curves
d) Compare and contrast non-witnessed and witnessed tests
e) Understand hydraulic test acceptance grades variances
f) Describe hydrostatic pressure test
g) Describe Maximum Allowable Working Pressure (MAWP)

A-12 Pump Installation, Commissioning, and Startup (4%)

a) Identify key elements of site drawings
b) Locate critical information in an instruction and operation manual
c) Identify key pump components and their item numbers in a parts manual
d) List general safety consideration for operating a pump system

e) Describe suitable pump foundation, grouting and anchoring as applicable for the installation
f) Explain startup checklist, personnel, data collection, system settings, and planned sequence of actions
g) Describe when priming is required

A-13 Maintenance (3%)

a) Cite steps in a typical maintenance program for a pump system
b) List tools and instruments typically required of pump system maintenance personnel
c) List general safety considerations for operating a pump system
d) Inspect mechanical seals and packing
e) Understand the need for calibration of instruments

A-14 Troubleshooting (3%)

a) List causes of insufficient pressure
b) List causes of insufficient rate of flow
c) List causes of increased power or power overload
d) List causes of high vibration (1x, 2x, vane-pass frequencies)
e) List causes of premature internal pump wear

A-15 Pump System Optimization and Analysis (2%)

a) Describe pump Life Cycle Cost (LCC), each component and typical hierarchy of costs
b) Define pump system optimization
c) List broad categories to optimize a pumping system (lower head, lower flow rate, improve installation, improve control, etc.)

A-16 Markets and Applications (2%)

a) List typical application considerations in market segment: Agricultural
b) List typical application considerations in market segment: Chemical
c) List typical application considerations in market segment: Commercial Building
d) List typical application considerations in market segment: General Industrial
e) List typical application considerations in market segment: Municipal
f) List typical application considerations in market segment: Oil and Gas
g) List typical application considerations in market segment: Power Generation
h) List typical application considerations in market segment: Residential