A single well servicing combination unit comprising: a hydraulic manifold removably connectable to the power-take-off of a power source to drive a plurality of hydraulic pumps and motors that control a plurality of well servicing modules that are removably mounted on said combination unit, said well servicing modules being interconnectable by plumbing.

**WISE CTN2 Unit Architecture**

![Diagram of WISE CTN2 Unit Architecture]

**Interface Color Code**
- (Black) CTN2 Control and Power
- (Blue) Optional Control
- (Red) Power Only
- (Green) Other (Fluid)
- Structural Interfaces not shown
FIG. 6

WISE Unit-Level External Interfaces

- OIL FIELD ROAD
- HIGHWAY SYSTEM
- CF CRANE AND SLINGS
- CF FORKLIFT
- CF TRUCK
- CF BOAT
- OPERATORS
- HYDRAULIC OIL
- DIESEL
- LUBRICANTS
- CF DRUM

- TUBING DEPLOYMENT INTO WELL
- NITROGEN WELL CONTROL
- SERVICING FLUID

- WASTE FLUID
- OTHER ENVIRONMENTAL IMPACTS

- HEAT TRANSFER WATER
- OIL

- MECHANICS MAINTENANCE EQUIPMENT SHOP

- DEPOT MAINTENANCE

- FIELD MAINTENANCE AND USE

- SERVICES
FIG. 8  Injector Performance (90GPM Pump – High Gear)
FIG. 9 Injector Performance (Low Gear)
WISE CTN2 Unit Architecture
FIG. 11

WISE CTN2 Unit Architecture

Interface Color Code
(Black) CTN2 Control and Power
(Blue) Optional Control
(Red) Power Only
(Green) Other (Fluid)
Structural Interfaces not shown
MODULAR WELL SERVICING COMBINATION UNIT

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a CONTINUATION IN PART of PCT Patent Application PCT/US07/06891 entitled “WELL SERVICING COMBINATION UNIT”, filed 20 Mar. 2007 at the USPTO, which is herein incorporated by reference. This application claims the benefit of US Provisional Patent Application entitled “WELL SERVICING MODULAR COMBINATION UNIT”, filed 19 Apr. 2007 at the USPTO, which is herein incorporated by reference.

FIELD

[0002] This invention relates, generally, to the treatment of oil and gas wells using fluids to increase the production capability of the wells, and more specifically, to providing for treatment of oil and gas wells with a means and apparatus that combines multiple modules—which may include: coiled tubing, nitrogen generation, fluid pumping, blending tanks, wireline inspection, and other modules—into a single unit.

BACKGROUND

[0003] It is known in the art to use self-powered units to provide wireline inspection and workover operations using gaseous nitrogen to remove sand and/or water or other impediments to production of oil and gas wells. The prior art has not recognized that a single, relatively small, engineless unit requiring minimal set-up/take-down time can be provided with all of the equipment and accessories for tapping into an onsite power source to run a compact and integrated system that may include one or more of the following: coiled tubing unit, nitrogen generator, fluid pumps, blending tanks, and wireline inspection unit, or other units.

[0004] The prior art equivalent typically brings as many as five transportation units (tractor-trailers, barges, or boats) to the well to be treated, one having a coiled tubing unit; one having either a liquid nitrogen tank or a large footprint nitrogen generation unit; one having the nitrogen pumping unit; one high pressure pumping unit for acids and other chemicals; and a separate wireline unit. Alternatively, the prior art may have a very large boat or barge with multiple units, each with its own power source. Separate, dedicated power sources for each unit drastically increases the mass and volume that must be transported. Current power packs are horsepower limited, which limits the equipment that each can drive. Conventionally, each of the five units above has its own engine. Even with a hydraulic power manifold to drive multiple units from a single engine, the horsepower limits how many can be integrated. The requirement for multiple (or much larger) transportation units increases the transportation costs, time, and personnel required to bring the units to the well and run these services.

[0005] U.S. Provisional Patent application 60/699,759 teaches a single, relatively small, self-powered unit with all of the equipment and accessories for running a nitrogen generation system and pressure pumping chemicals to treat wells.

[0006] U.S. Pat. No. 6,230,805 (Vercamert) teaches a method of hydraulic fracturing in which at least two separate fracturing fluid components are pumped downhole—one of said components being pumped downhole within coiled tubing—but does not teach how to accomplish this with a single compact unit in which all equipment is powered by an onsite engine and that also provides for the coil tubing operation and wireline inspection.

[0007] U.S. Pat. No. 6,273,188 (McCafferty) teaches a trailer mounted coiled tubing rig.

[0008] U.S. Pat. No. 6,702,011, also by the present inventors, teaches a combined nitrogen treatment system and coiled tubing system in one tractor/trailer apparatus. A single tractor-trailer unit is provided, in which the tractor itself drives a plurality of hydraulic motors that control the pumps and motors associated with a nitrogen system that is used for injecting nitrogen into a well. A crane unit and a coiled tubing injection unit are also provided. Unlike the present invention, no disclosure is made for the provision of wireline inspection, well servicing fluid tanks, mixers, and pumps. Unlike the present invention, the preferred type of nitrogen system is tanks of liquid nitrogen, although an alternative mode is disclosed in which the liquid nitrogen system is replaced with one or more nitrogen generators that gather nitrogen from the earth’s atmosphere. However, it was not disclosed, as in the present invention, that the nitrogen could be mixed with well servicing fluids provided by the same unit.

[0009] PCT Application US2004/034521 teaches a three in-one nitrogen treatment system, fluid system, and coiled tubing system in one unit. A single tractor-trailer or marine unit is provided, but unlike the engineless present invention, an onboard engine drives a plurality of hydraulic motors that control the pumps and motors associated with a nitrogen system and a fluid system that is used for injecting nitrogen and fluid into a well. Like the present invention, a coil tubing system is also provided. The only means disclosed for pumping fluid to the well is through the coil tubing system and no disclosure is made for the injection of well servicing fluids directly into the well, and no fluid blending tank is disclosed. Also, no means for wireline inspection is provided.

[0010] The off-shore prior art that has the same functionality as the present invention is larger, more expensive, and requires either multiple barges or ships—necessitating additional time and expense for set up and take down of the ship to ship plumbing—or a larger, more expensive barge or ship that has a deeper draft and can therefore depart from and reach fewer locations.

[0011] The primary object of this present invention is to provide a small engineless unit that can be placed on a single small barge or ship or a single tractor-trailer or marsh buggy and use an onsite power supply to provide wireline inspection, coil tubing operations, and nitrogen generation and pump a combination of high pressure nitrogen and acids or other chemicals into wells. The configuration of the present invention on a marsh buggy could be nearly identical to the configuration on a boat or barge. Combination of multiple units such as a wireline, coil tubing unit, nitrogen generator with fluid pumping and mixing on a single transportation unit and all powered by an external power source through a single onboard custom hydraulic manifold is not known in the prior art to the best of the inventor’s knowledge.

[0012] The primary object of the present invention is to provide a modular well servicing unit that can be placed on a single tractor-trailer, amphibious vehicle, or a small barge or ship.

[0013] The approaches described in this section are approaches that could be pursued, but not necessarily approaches that have been previously conceived or pursued. Therefore, unless otherwise indicated, it should not be
assumed that any of the approaches described in this section qualify as prior art merely by virtue of their inclusion in this section.

SUMMARY

[0014] A single well servicing combination unit comprising: a hydraulic manifold removably connectable to the power-take-off of a power source to drive a plurality of hydraulic pumps and motors that control a plurality of well servicing modules that are removably mounted on said combination unit, said well servicing modules being interconnectable by plumbing.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] These and other features, aspects, and advantages of the present invention will become better understood when the following detailed description is read with reference to the accompanying drawings in which like characters represent like parts throughout the drawings, wherein:

[0016] FIG. 1 is a top view diagram of the lay out of a 105 class jack-up boat with a custom hydraulic manifold, wireline inspection module, coil tubing module, crane, mixing tank module, storage tank module, fluid pump with power pack, operator console module, and nitrogen generation module, in accordance with an embodiment of the present invention.

[0017] FIG. 2 is an elevated, block diagram side view of the deck of the boat from FIG. 1, that shows a nitrogen generation module that is connected to the discharge line at a tee, and storage, mixing, and pumping modules for well servicing fluid connected to said discharge line at said tee, in accordance with an embodiment of the present invention.

[0018] FIG. 3 illustrates, in block diagram, the various systems that are used in accordance with the present invention to treat a well with nitrogen and well servicing fluid, in accordance with an embodiment of the present invention.

[0019] FIG. 4 is a pictorial view of three nitrogen generator modules, in accordance with an embodiment of the present invention.

[0020] FIG. 5 is a pictorial view of a module using membrane technology to pull gaseous nitrogen out of the atmosphere, in accordance with an embodiment of the present invention.

[0021] FIG. 6 shows the external interfaces of the entire WISE\textsuperscript{TM} Unit including customer-furnished modules, in accordance with an embodiment of the present invention.

[0022] FIG. 7 shows the external interfaces of a subset of the entire WISE\textsuperscript{TM} Unit, in accordance with an embodiment of the present invention.

[0023] FIG. 8 shows injector head performance, in accordance with an embodiment of the present invention.

[0024] FIG. 9 shows injector head performance, in accordance with an embodiment of the present invention.

[0025] FIG. 10 is a block diagram of a WISE\textsuperscript{TM} Unit including a coil tubing deployment module, injector head module, and well control stack module, in accordance with an embodiment of the present invention.

[0026] FIG. 11 is a block diagram of a WISE\textsuperscript{TM} CTN2 Unit including a coil tubing deployment module, injector head module, and well control stack BOP Module, in accordance with an embodiment of the present invention.

DESCRIPTION

[0027] The preferred embodiment of the present invention is the “WISE\textsuperscript{TM} Unit”, comprising a plurality of modules and components.

[0028] The “WISE\textsuperscript{TM} Unit” is the entire package of equipment delivered.

[0029] Example configurations:

[0030] a WISE\textsuperscript{TM} 2 Unit, or

[0031] an OFFSHORE WISE\textsuperscript{TM} Unit

[0032] A “Module” can be any of the removably connectable major parts of the “WISE\textsuperscript{TM} Unit.” Examples:

[0033] the CT Module,

[0034] the Nitrogen Module,

[0035] the Operator Control Module

[0036] the power pack module

[0037] A Component is a sub part of a Module. This specification defines components only to the extent necessary for manufacturing or operational flexibility.

[0038] EXAMPLES

[0039] Pumps

[0040] Cranes

[0041] Valves

[0042] Gauges

[0043] The WISE\textsuperscript{TM} CT SGN2 unit’s architecture (also called the “WISE\textsuperscript{TM} Architecture”) allows the insertion of different servicing modules (i.e., coiled tubing, self-generating nitrogen, and servicing fluid pumps) when ordering future WISE\textsuperscript{TM} Units without redesign of other Modules (i.e., operator control module, transportation modules, and power packs).

[0044] The WISE\textsuperscript{TM} Unit’s architecture and design documentation allow substitution of major Modules and Components supplied by one manufacturer with Modules and Components meeting the same specifications supplied by another manufacturer to take advantage of shorter lead times. A system integrator approach is enabled by completely modularity. Every piece of well intervention equipment becomes a Module to be “integrated” into a working unit. This gives WISE\textsuperscript{TM} flexibility of design without sacrificing producibility of design (manufacturability—standards) and has direct impact on depot maintenance program and reduces the number of different spare parts in inventory (Standardization).

[0045] This specification uses the terms “vendor” and “manufacturer” interchangeably.

[0046] Referring now to FIG. 1, a top view of jack-up boat 10 having either a gasoline engine or a diesel engine is illustrated. Mounted on the boat deck 30 is nitrogen generator module 31 (also shown in FIG. 4) that extracts nitrogen from the atmosphere to eliminate the need for (and the associated cost of) transporting and filling nitrogen tanks. Mounted to boat deck 30 are chemical storage tank modules 42 that supply chemicals to blending tank modules 50 where the chemicals are mixed. The mixed chemicals flow to the well servicing fluid pump module 48. The mixed chemicals may flow through the coil tubing 82, 50 to the well head. Wireline inspection module 52 is mounted to deck 30. Also mounted on the deck 30 is control cabin module 34 in which the electrical and hydraulic modules 36 are controlled by a human operator. Components are described in greater detail in the description of FIG. 2 below.

[0047] Referring now to FIG. 2, a diagram of a jack-up boat 10 is illustrated. Mounted on the boat deck 30 is a custom hydraulic manifold 70 that distributes power from an external power source 200 to all engineless modules on deck 30—ni-
trogen air feed module 32, injector module 44, crane module 46, well servicing pump module 48, blending tank module 50, and Wireline module 52. Mounted on deck 30 is a feed air system 32 that is connected to nitrogen membranes 33. Together, the feed air system 32 and nitrogen membranes 33 function as a nitrogen generator module 31 (also shown in FIG. 4) that extracts nitrogen from the atmosphere to eliminate the need for (and the associated cost of) transporting and filling nitrogen tanks. In the preferred embodiment, nitrogen generator module 31 utilizes a membrane 33 (also shown in detail in FIG. 5) that allows nitrogen-rich air from the earth’s atmosphere to be continuously fed into the bundle housing. The air reaches the center of the bundle of membrane fibers which, at that point, consists mostly of gaseous nitrogen. The nitrogen collects in the mandrel at the center of the bundle. As the air passes through the bundle of membrane fibers, the oxygen and other fast gases pass through the wall of the membrane fibers as the fast gases go through to be collected at the end. Oxygen, water vapor, and the other fast gases are continuously collected and are moved from the bundle, thus leaving the nitrogen available to be used for injection into the well being treated. This occurs at near ambient pressure and temperature. It is an advantage of this embodiment that large volumes of nitrogen can be provided at the well site to be pumped into the well, without the need to transport that entire volume in either liquid or gaseous form to the well site. The nitrogen generator modules 31 of the preferred embodiment accomplish this nitrogen generation with a smaller footprint than any prior art the inventor knows. The nitrogen then flows to the nitrogen booster compressor 38 that then compresses the dry nitrogen to the desired pressure. The nitrogen will then be pumped to the tee 39 where it mixes with a fluid or a fluid mix, such as an acid, and then the resulting mixture enters the discharge line 41. The nitrogen in the discharge line may be either liquid or gas. Mounted to boat deck 30 are chemical storage tank modules 42 that supply chemicals to blending tanks 50 where the chemicals are mixed. The mixed chemicals flow first to the centrifugal pump 47 and then to the well servicing fluid pump module 48. The mixed chemicals flow to the tee 39 where the mixed chemicals mix with nitrogen and the resulting mixture flows into the discharge line 41. From the discharge line 41 the resulting mixture can flow directly to the well head or through the coil tubing 55 to the well head. An injector module 44, also described in more detail hereinafter, is situated on the boat deck. A hydraulically driven crane module 46 is also situated on the boat deck for situating the coiled tubing injector module 44 immediately above the well being treated. A hose reel module 45 and a coiled tubing reel module 55 are situated on the deck 30. A goose neck module 53 is also situated on the deck 30 adjacent the coiled tubing injector module 44 for feeding the coiled tubing from the reel into the injector. A stripper 54 is located on the lower end of the coiled tubing injector system 44 for enabling the coiled tubing 55 to be placed into the well being treated. A blow out preventer module 56 is also located on the boat deck to be used in shutting in the well to be treated, if needed. Wireline inspection module 52 is mounted to deck 30. Also mounted on the deck 30 is a control cabin 34 in which the electrical 36 (not shown) and hydraulic modules 70 are controlled by a human operator. Referring now to FIG. 3, there is illustrated in block diagram some of the components that are illustrated in FIGS. 1 and 2.

The nitrogen air feed module 32 has its output connected into the input of a hydraulic pump 90. The custom hydraulic manifold 70, which may be connected to either a gasoline powered or diesel powered external power source or marine mobile power pack 200, has a return line 74. A hydraulic pump 90 is connected into a hydraulic motor 92 that is used to drive the return line 74. A hydraulic pump 96 is connected into a hydraulic motor 98 that is used to drive the chains of the injector module 44 that can either move the coiled tubing into the well being treated or pull the coiled tubing out of the well being treated, as desired, depending on the direction of the chain rotation.

Another hydraulic pump 100 drives a motor 102 to drive the crane 46 illustrated in FIG. 2.

Another hydraulic pump 110 drives a motor 112 to power the well servicing pump 48, which is illustrated in FIG. 2.

Another hydraulic pump 116 drives a motor 118 to power the blending tank modules 50, which are illustrated in FIG. 2.

Another hydraulic pump 122 drives a motor 124 to power the wireline inspection module 52, which is illustrated in FIG. 2.

It should be appreciated that from the power take-off of a power source 200, a custom hydraulic manifold distributes power to each of the five modules. Said power source with a power take-off 200 routed through custom hydraulic manifold 70 drives each of the hydraulic pumps 90, 96, 100, 116 and 122 as shown by the line 106. Coming off of the custom hydraulic manifold 70, the hydraulic pumps 90, 96, 100, 116 and 122 are preferably driven by one or more belts that can be used with clutch pulleys as desired. The compressor module 108 is also driven by the custom hydraulic manifold 70 via the drive line 106 to bring the nitrogen down to its desired temperature. By using a power take-off on the vessel (rig, platform, work boat, tug boat, or jack up barge) that is already on site, that power source 200, with over 1000 horsepower available, can drive more machines than a less powerful onboard source could.

The preferred embodiment of the present invention can operate with a separate land or marine external power source. As long as the preferred embodiment of the present invention can avail itself of an adequate power source it can do all of the following well servicing, including but not limited to:

- Completions
- Workovers
- Underbalanced drilling
- Well servicing
- Enhanced oil recovery
- Industrial plant degassing and purging
- Mining
- Purging pipelines with nitrogen
- Deepwater marine applications
- LNG & LPG tanks and facilities
- Nitrogen lifting, the flooding wells that won’t flow with nitrogen
- Nitrified Acid
- Nitrogen Displacement
- Pipeline testing
- Tubing testing
- Acidizing
- Cleanouts
- Fix sanding up—Paraffins—Foam wash
- Jet with nitrogen
- Nitrify acid
- Nitrogen inhibitor
Wireline Inspection

One advantage of the present invention is that it makes it possible to do with one unit and a single power source what previously required five separate powered units—a wireline inspection unit, a coiled tubing unit, a liquid nitrogen tank transport means, a powered unit with a high pressure pumping system for other chemicals and acids, and a unit with a nitrogen pumping means. Because this embodiment allows one unit to do what once required several powered units connected together with the requisite hoses and plumbing, the time and expense of plumbing rig-up is avoided. Disconnecting and storing all of the plumbing after completion is also avoided, saving additional time and labor. Where the prior art would have taken several units and several days (for set-up, inspection, well treatment, and disassembly), the preferred embodiment of the present invention can do the same job with one unit in one day. The present invention saves the trouble and expense of transporting five separate power sources to the site, each of which takes up over sixty square feet of deck space, allowing this combined unit to be smaller and cheaper than any prior art equivalent. The smallest existing vessel with a coil tubing unit is a 175 class boat, yet an embodiment of the present invention with an integrated coil tubing module along with four other integrated modules can be placed on a single 105 class boat. The deck load of the prior art equivalent would be about 150,000 pounds, yet an embodiment of the present invention has a deck load of only about 50,000 pounds, allowing operations in shallower water. The danger of transporting liquid nitrogen, which is an explosion hazard, is also avoided. Hazards associated with running plumbing and hoses from boat to boat are also avoided, and fewer personnel are required. As far as the inventor knows, the preferred embodiment of the present invention has a smaller footprint and lighter weight than any functional equivalent.

The preferred embodiment of the present invention is even more advantageous in remote locations where liquid nitrogen is rare and expensive, or extremely difficult to transport to the well head.

The invention is well suited for off shore use. Because of its small footprint, this invention allows replacement of large, expensive vessels with much smaller and cheaper barges or ships that have shallower drafts.

It should be noted that while the embodiment described so far is powered by a prime mover such as a marine mobile power pack, the invention can also be mounted on and use the engine of a truck power pack and is equally suited for on shore use. An embodiment of the present invention may be trailerered on land, to replace as many as five separate units and realize similar time and cost savings.

Another embodiment of the present invention comprises an onshore-offshore convertible WISE™ Combination Coiled Tubing (CT) and Nitrogen (NG2) Unit with a Self-Generating Nitrogen (SGN2) Module. This WISE™ Unit is called the “WISE™ CT SGN2 ONSHORE-OFFSHORE CONVERTIBLE UNIT” abbreviated as “CT SGN2.”

In the offshore configuration, a Truck Power Pack will tow a crane trailer module loaded with modules such as an Operator Control Module, Coiled Tubing Deployment Module, Injector Head Module, Well Control Stack BOP Module, and SGN2 Nitrogen Module to and from well servicing sites. At well servicing sites, the Truck Power Pack will power the servicing equipment.

An advantage of the present invention is that customer-furnished equipment (CFE) can be provided to be integrated into the WISE™ Unit, allowing a high degree of customization and cost savings. Changes to the unit configuration can be made much later in the manufacturing/assembly process, or even after the unit is in use in the field. Reconfiguration between On-Shell and Off-Shore Jobs

This WISE™ Unit can be deployed for both onshore and offshore jobs:

The onshore subset of this WISE™ Unit is a truck power pack that tows all servicing modules mounted on a crane trailer to the job site and then powers the servicing equipment on the job site.

The offshore subset of this WISE™ Unit is the operator control module and servicing modules removed from the onshore crane trailer plus marine mobile power pack. These modules are transported on a customer-furnished truck to port and on a customer-furnished boat to an offshore oil platform. On the offshore oil platform, the marine mobile power pack supplies all power required for the WISE™ Unit.

By itself, the marine mobile power pack can be used as a backup or substitute for the WISE™ III marine power pack.

Reconfiguration for Different Well-Servicing Functions

In the onshore configuration, the WISE™ CTN2 Unit can be augmented by an independently-powered fluid pump (customer-furnished) to deliver servicing fluid or nitrified servicing fluid into the well.

In the offshore configuration, the WISE™ CTN2 Unit provides fluid pumping from its Marine Mobile Power Pack to deliver servicing fluid or nitrified servicing fluid into the well.

The WISE™ Unit can be reconfigured for different well-servicing functions at the maintenance depot level. The cryogenic liquid nitrogen module can be replaced by or augmented by a fluid servicing pump without modifying the operator control module.

In the preferred embodiment, to facilitate modularity the following interface standards are universal throughout all of the WISE™ units. These standards govern connections between the Operator Control Module and other modules within the WISE™ Unit.

---

**Equipment Interface Table**

<table>
<thead>
<tr>
<th>Equipment Interface Table</th>
<th>Air Pneumatics</th>
<th>Hydraulic Fluid</th>
<th>Water Glycol</th>
<th>Vaporization Loops</th>
<th>Water Glycol</th>
<th>Vaporization Loops</th>
<th>Liquid Nitrogen</th>
<th>Gaseous Nitrogen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3/8&quot; and Smaller</td>
<td>&quot;Parker&quot; 30 Series QD couplers &amp; Industrial Interchange Nipples</td>
<td>1&quot; Industry Standard &quot;crow's foot&quot; couplers</td>
<td>“Parker 6600 QD Couplers and Nipples”</td>
<td>“Snap-Tite” 7S Series Wing Type QD Couplers and Nipples</td>
<td>“Snap-Tite” VH Series QD Couplers and Nipples</td>
<td>“150N Acme Thread Couplers and Nipples”</td>
<td>Figure 1502 Hammer Unions</td>
</tr>
</tbody>
</table>

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-continued

<table>
<thead>
<tr>
<th>Equipment Interface Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well Treatment Fluids</td>
</tr>
<tr>
<td>120/220 VAC Electrical</td>
</tr>
<tr>
<td>Power</td>
</tr>
<tr>
<td>DC Instrumentation</td>
</tr>
<tr>
<td>12 VDC Power</td>
</tr>
</tbody>
</table>

Functional and Performance Requirements

Nitrogen Delivery

[0084] The WISE™ Unit will preferably provide nitrogen at a discharge pressure ranging from 0-7500 psig and at an operator-controllable flow rate ranging from 0-850 scfm, while maintaining the discharge temperature at 10°F above ambient.

Onshore Configuration

[0085] In the onshore configuration, the WISE™ Unit will preferably transfer servicing fluid from an independently-powered, customer-furnished source to the well via 2-inch pipe with 1502 Hammer unions compatible with well-serving fluids.

<table>
<thead>
<tr>
<th>TABLE CTN2-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circuit</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>acid</td>
</tr>
<tr>
<td>cement</td>
</tr>
<tr>
<td>sand slurry</td>
</tr>
</tbody>
</table>

Offshore Configuration

[0086] In the offshore configuration, the WISE™ Unit will preferably pressurize and transfer servicing fluid from a customer-furnished source to the well via the CT at an operator-controllable flow rate ranging from 0-50 gpm and a pressure ranging from 0-5000 psig.

Transportability Requirements

[0087] In between well interventions, the Truck Power Pack will tow the WISE™ Unit trailer (comprising for example: a crane trailer loaded with an Operator Control Module, Coiled Tubing Deployment Module, and Nitrogen Module) to and from well servicing sites.

[0088] The Unit travels over a wide range of roads, paved and unpaved, between well-serving jobs. The Unit should be configured for transportation to minimize need for special permits in onshore and offshore configurations.

[0089] At well servicing sites, the Unit can operate beyond its transportation envelope with an operator-extended crane and other extensions such as coolers or open ventilation doors.

[0090] The Unit may be Shipped Overseas.

[0091] Well servicing modules can be installed onto the Onshore Transport Trailer Module with cranes or forklifts.

Onshore

[0092] The WISE™ Unit can provide self-contained onshore transportation for the onshore configuration. An embodiment of the onshore configuration comprises all modules except the offshore marine mobile power pack, transportation skid kit, and hose basket with offshore hose bundle.

[0093] In the preferred embodiment of an onshore transportation configuration, the WISE™ Unit should preferably have a total height less than 13 feet, 6 inches.

[0094] In the preferred embodiment of an onshore transportation configuration, the WISE™ Unit should preferably have a total width of less than 8 feet, 6 inches.

[0095] In the preferred embodiment of an onshore transportation configuration, the WISE™ Unit should preferably have a total length of less than 64 feet.

Offshore

[0096] The preferred embodiment of a marine mobile power pack should preferably be transportable on trucks.

[0097] In the preferred embodiment, it is preferable that no single skid in the offshore transportation configuration weigh more than 18,500 pounds, except for the coil tubing drum loaded with coil tubing in its transportation skid.

[0098] In the offshore configuration, the WISE™ Unit should preferably weigh less than 85,000 pounds including one full cryogenic nitrogen storage vessel and 10,000 feet of 1¼” coil tubing.

Onshore To Offshore Conversion

[0099] The WISE™ Unit should preferably be designed so that the following modules and components can be removed from its onshore transportation trailer for separate transport to an offshore site:

- [0100] operator control module
- [0101] coil tubing deployment module
- [0102] cryogenic liquid nitrogen module except cryogenic liquid nitrogen storage vessel

[0103] The goal for this onshore to offshore conversion is completion in 8 hours using a three-person operations crew and the following equipment:

- [0104] customer-furnished forklift
- [0105] customer-furnished crane
- [0106] Transportation Skid Kit included with the WISE™ Unit
- [0107] Hose Reel Skid included with the WISE™ Unit

Offshore to Onshore Conversion

[0108] The goal for this onshore to offshore conversion is completion in 24 hours using a three-person operations crew and the following equipment:

- [0109] customer-furnished forklift
- [0110] customer-furnished crane
- [0111] Transportation Skid Kit included with the WISE™ Unit
- [0112] Hose Reel Skid included with the WISE™ Unit

Availability and Reliability

[0113] Overall WISE™ Unit availability is a function of the WISE™ Unit reliability and maintenance and logistics systems. “Availability” is defined as the WISE™ Unit being ready for transit between well-servicing sites and for per-
forming well-servicing activities. Increasing availability of units minimizes maintenance down time and increases utilization rate. By keeping modules at the depot in inventory, a “broken” module is simply replaced by a certified working. This keeps a unit in service more days per month but with no additional fixed costs (such as crew, etc.). Taking this maintenance approach improves unit availability (utilization).

WISE™ Unit Maintainability Requirements

[0114] The WISE™ Unit should preferably provide well services for 12 hours without refueling.

[0115] The WISE™ Unit should preferably require no preventive maintenance beyond that described in Appendix C, Customer Maintenance Program.

Growth Requirements

[0116] The WISE™ Unit should preferably incorporate the following provisions (hardware “scars”) for the post-deployment addition of a well servicing fluid pump integrated into the onshore configuration:

[0117] operator control module fluid pump control

WISE™ Architecture and Design Constraints

Module Definition

[0118] The complete WISE™ Unit has the following modules integrated:

[0119] One (1) Operator Control Module
[0120] One (1) Truck Power Pack
[0121] One (1) Trailer with Crane for Onshore Operations
[0122] One (1) Coiled Tubing Deployment Module (Reel assembly) with major components:
[0123] One (1) Coiled Tubing Reel Skid (cf/e)
[0124] One (1) Coiled Tubing Reel Drum (cf/e)
[0125] Tubing (cf/e)
[0126] One (1) Injector Head Module (cf/e)
[0127] One (1) Well Control Stack (Blow Out Preventor (BOP) Module (cf/e)
[0128] One (1) Cryogenic Liquid Nitrogen Pumping Module
[0129] One (1) Marine Mobile Power Pack
[0130] One (1) Crew Cab Truck (cf/e)
[0131] One (1) Tools (cf/e)
[0132] One (1) Electrical Generator
[0133] One (1) Transportation Skid Kit
[0134] One (1) Hose Reel Skid

3.2 Internal Interfaces

[0135] Interface P-1 and P-2 should preferably be identical for hydraulics and electrical.
[0136] Interface P-2 should preferably be identical to the interface between the WISE™ III power pack and the remainder of the WISE™ III Unit.

Module-Level Requirements

[0137] The following sections contain the requirements for the modules and their major components.

Operator Control Module

[0138] The Operator Control Module (WISE™ Power Management Module) represents the core of the WISE™ technology principal of central control and operation of multiple well-serving functions from a single power source and control point. Mated with the appropriate power sources and ancillary equipment packages, this module monitors and controls: Coiled Tubing Deployment, Cryogenic Nitrogen, and Fluid Pumping Operations (if installed).

[0139] The Operator Control Module should preferably provide:

1. Operator Control and Monitoring interface for entire WISE™ Unit except crane
2. Electrical power transformation (120 VAC to 12 VDC) and distribution to all systems needing electrical power
3. Hydraulic power distribution control to all well-servicing modules and crane
4. Heat transfer water and glycol distribution to N2 (if installed).
5. Well servicing fluid distribution and control in offshore configuration.
6. Well servicing fluid control if integrated in onshore configuration (see 2.11, Growth Requirements).

[0140] Note that external customer-furnished fluid pumping is not controlled by the operator control module.

[0141] The Operator Control Module should preferably be a skid-mounted module with a crash frame; forklift guide tubes and a four point sling lift attachment points. Lifting slings are CFE.

[0142] In the transportation configuration, the Operator Control Module should preferably be 96" long x 96" wide with height to allow 13'6" height clearance when loaded on a 48" tall truck trailer. The Operator Control Module should preferably weigh 15,500 lbs or less.

[0143] The Operator Control Module should preferably operate in the offshore well servicing environment.

[0144] The Operator Control Module should preferably operate in the onshore well servicing environment.

Operator Control and Monitoring

Telescoping Operator Control Cabin

[0145] The control cabin shall:

[0146] Telescope upward to an operator-controllable height (up to 5' maximum extension) from the volume of the transportation skid. (to provide operator with visibility of well-servicing operations)

[0147] Be 84" wide x 84" long (interior)

[0148] Have two (2) side access doors for operator entry with stainless steel door hardware, fixed windows in doors, and rain gutter above doors.

[0149] Have operator access by ladder on one side and steps on the other

[0150] Have front window protected with hinged metal guard that can be fully removed by operator.

[0151] Have fixed side wall windows.

[0152] Have Sliding rear windows.

[0153] Have tempered safety glass in all windows.

[0154] Have all windows tinted.

[0155] Light its interior with one (1) 110 volt interior fluorescent lamp

[0156] Contain an unmounted, portable office-style chair with armrest for operator comfort.

[0157] Contain a 48" wide bench seat along rear of cabin with removable to access storage below bench seat.

[0158] Contain one (1) chart recorder of a two (2) pen type Well Head Pressure and Circulating Pressure.
Be cooled by one (1) through the wall Air Conditioner of 12,000 btuh cooling capacity.

Interface with electrical distribution via one (1) electrical junction box for 110/220 volt power connection for Lighting and Air Conditioner.

Contain a Control Console of an open "L" shape having a lower section sloped and an upper near vertical section running along the front of the cabin so that operators in both sitting and standing positions can read all instruments and move all controls through their full ranges.

Operator Interface
Controls and Indicators

The preferred embodiment of the control console module provides the following controls and indicators for the operator:
1) 6-Bank BOP control valve with a single function handles. BOP control valves should preferably be labeled from left to right "Blinds", "Cutters", "Slips", "Pipe", "Aux Pipe" and "Blind Shears". BOP's to have an emergency back-up circuit from an air or hand operated in cabin pump.
2) BOP Circuit Master Push/pull Actuation Valve and Pressure Gauge
3) 5-Bank valve panel with integral locking Walvoil type SD6 valves in corner of console for remote plug valve operations. Valves to be labeled "BOP Kill", "Aux Kill", "Return", "Spare 1" and "Spare 2"
4) Air Regulator Valve and Air Supply Gauge for Stripper Pack-off Air over Hydraulic Pump.
5) Stripper Circuit Air Drive pump with emergency manual operator.
6) Snap-Tite Stripper control valve and Stripper circuit hydraulic pressure gauge.
7) Injector Weight Indicator mounted in center of Panel Upper section. Indicator should preferably read 60,000 lb pipe heavy and 15,000 lb pipe light.
8) Single Pressure Regulator Valve and isolation valves with circuit pressure gauges for three (3) injector traction circuits.
9) Emergency Accumulator systems for:
a) injector traction circuits with full pressure activation valve
b) injector head skew system chain tension circuits with TBD valve
10) Single Pressure Regulator Valve and isolation valve with circuit pressure gauge for a single injector chain tension circuit.

Gresen (Munson-Tyson Type) Control Valve for Injection speed and direction, with Cartridge valve for fine control of injector speed. (Auto-driller arrangement)

Selector Valves for Injector speed range and injector brake circuit with status indicator gauges.

Pressure Control Valve for Setting Injector Power Circuit pressure with gauge.

Needle Valve for injector chain oiler control.

Three (3) single bank directional control valves for Tubing Reel Pay-Out and Take-Up; Levelwind Raise and Lower; and Levelwind Override.

Pressure Control Valve for Reel tension Control with tension pressure gauge.

Control Valve for reel brake circuit with pressure gauge.

Two (2) 6" face 4:1 ratio 15,000 psig reading pressure gauges, One (1) for circulating pressure to the left of weight indicator and one (1) for well head pressure to the right of the weight indicator.

Air operated controls for power pack engine throttle, shutdown and emergency kill.

Power Pack Engine remote instrumentation Package to include, Tachometer, Coolant Temperature.

Cryogenic Nitrogen Centrifugal Boost Pump Speed control Valve.

N2 Boost Pump hydraulic pressure gauge.

N2 Boost Pump LN2 discharge pressure gauge (150 psi) with debooster or remote sender to protect operators from cryogenic N2 exposure in case of gauge or gauge plumbing failure.

N2 tank discharge (vaporizer inlet) pressure gauge (10,000 psi) with debooster or remote sender to protect operators from cryogenic N2 exposure in case of gauge or gauge plumbing failure.

Cryogenic Nitrogen Triplex Injection Pump Speed control valve (warm end).

N2 Triplex pump hydraulic pressure gauge.

N2 Triplex pump LN2 discharge pressure gauge.

Auxiliary Heat Load Hydraulic Pressure Control Valve.

Auxiliary Heat Load Hydraulic Pressure Gauge.

Remote Air Operated Low Pressure LN2 Prime to Atmosphere control valve.

Remote Air Operated Low Pressure LN2 bypass to tank control valve.

Remote Air Operated High Pressure LN2 bypass to tank control valve.

Remote Air Operated High Pressure GN2 tempering control valve.

The hydraulic controls should preferably be rated for operation at 3000 psi working pressure.

Hydraulic Distribution

The hydraulic distribution component of the operator control module should preferably include:

Permanently installed hoses from the control cabin bulkhead for connection to the following:

Injector main drive hoses—power pack to rear of trailer plus extensions to the hose reel.

Reel pivot hose

BOP control hoses installed with extensions to the hose rack

Injector control hoses installed with extensions to the hose rack

Reel control jumber hoses

Two (2) 15 gallon accumulators for BOP circuits mounted inside trailer frame rails.

The hoses should preferably be labeled at each end with bands imprinted with customer-specified text and by numbered stainless steel washers.

Electrical Transformation and Distribution

The electrical distribution component of the operator control module should preferably distribute 120 VAC from the electric generator to the listed components at no more than listed current:
the control cabin air conditioning component (10.0 amps)

[0178] the control cabin lighting (2.0 amps)

[0179] The electrical distribution component of the operator control module should preferably distribute 120 VAC from an offshore platform supply to the listed components at no more than listed current:

[0180] the control cabin air conditioning component (10.0 amps)

[0181] the control cabin lighting (2.0 amps)

[0182] The electrical distribution component should preferably transform 120 VAC to 12 VDC and distribute 12 VDC to:

[0183] monitoring instrumentation

Heat Transfer Water-Glycol Distribution

[0184] The Water-Glycol Distribution component should preferably distribute a water and glycol mix from the power pack to the cryogenic liquid nitrogen modules via the hydraulics heat exchanger.

Well-Servicing Fluid Distribution and Control

[0185] In the off-shore configuration, the operator control module shall:

[0186] Control the well-servicing fluid pump in the marine mobile power pack

[0187] Distribute well-servicing fluid from the power pack to the CT

Truck Power Pack

[0188] An over-the-road truck tractor provides onshore transportation and onshore power to the hydraulic systems for all Coiled Tubing and Nitrogen Modules.

[0189] The truck power pack should preferably tow the trailer containing the crane and well-servicing modules to onshore well servicing sites and maintenance locations.

[0190] At the well-servicing site, the truck power pack should preferably provide hydraulic power to concurrently operate the coiled tubing and nitrogen modules at their maximum capabilities described in section 2.2 (functional and performance requirements).

[0191] The truck power pack should preferably operate in the onshore well servicing environment.

[0192] The truck power pack consists of a Freightliner 515-hp Detroit Diesel series 60, 14.0 L. tractor with 10-speed transmission plus “wet kit” consisting of: an auxiliary transmission, a pair of PTO’s, a hydraulic reservoir, a glycol reservoir, fluid coolers, hydraulic pumps, and various hoses, fittings, and control valves. Its features include:

[0193] 515 peak Horsepower Tractor Engine

[0194] Full power capacity driveshaft driven auxiliary transmission with forward and rear facing hydraulic pump mounts.

[0195] Two (2) truck transmission mounted PTO’s.

[0196] Two (2) axial piston pressure compensated hydraulic pumps, one for Nitrogen Modules, and one to drive the Coiled Tubing Injector Head.

[0197] One (1) single vane hydraulic pump to serve dual purposes, powering either the pedestal crane, or an auxiliary heat load circuit.

[0198] One (1) double-vane hydraulic pump, with one (1) circuit dedicated to the coiled tubing reel hydraulics distribution, and one (1) circuit dedicated to BOP and safety control modules hydraulic distribution.

[0199] One (1) double-gear glycol and water pump for circulation of water glycol mixture for LN2 vaporization.

[0200] Multiple baffled hydraulic reservoir with integral return filters, strainers and connection points for truck power pack to trailer.

[0201] Two (2) hydraulic fan powered fluid coolers.

[0202] One (1) glycol reservoir and expansion chamber.

[0203] Major components of this module are the Transport Trailer and Crane.

[0204] The OnShore Transport Trailer with Crane should preferably operate in the onshore well servicing environment.

Transport Trailer

[0205] Preferably, a 48 ft long single drop-deck triple-axle trailer provides the transportation and work platform for all the well servicing equipment and a hydraulic pedestal crane.

Trailer

[0206] Trailer specifications are:

[0207] Three air ride axles with third (rearmost) axle set up with a dump valve to shorten effective trailer turn radius.

[0208] 48 ft long single drop deck trailer with 11 ft long upper deck, 37 ft lower section.

[0209] Upper deck should preferably be plate, lower section should preferably be bare frame rails.

[0210] 8' width

[0211] 12' minimum ground clearance

[0212] Standard king pin setting

[0213] Landing legs 160,000 lb.

[0214] Three (3) each 25,000 lbs. Axles (minimum)

[0215] Brakes 16 3/8 x 7 air type

[0216] Michelin tires or equivalent 11R24.5

[0217] Parking brake air chambers mounted above axles

[0218] 3 1/4 " SAE King pin with 3/8 rub plate

[0219] Lights, stop/tum armored clearance

[0220] Mud flaps

[0221] Rear bumper

[0222] Running lights for highway use

Equipment Mounts

[0223] Complete equipment mounts installed on the trailer should preferably allow quick pin-on and rig-up of equipment:

[0224] Well control stack

[0225] Injector head

[0226] All skidded equipment

[0227] Tool boxes

[0228] Injector head and well control stack equipment mount should preferably be within the crane's operating envelope. As shown in FIGS. 8 and 9, the injector may be operated continuously at the intersection of any speed and pull combination as long as the intersection remains on or to the left and below of the 100 hp continuous output curve.
Inject head mount should preferably position the HydraRig 635 inject head so that the COIL TUBING can remain stabbed during transport between well servicing sites.

Mounting brackets and setups should preferably secure one 1800-gallon cryogenic liquid nitrogen tank (tank itself is described in nitrogen module specification).

A hydraulically-operated pedestal crane (such as: National Crane Model 638, 18 ton Pedestal Crane) should preferably be installed on the crane trailer.

Specifications of the Crane are:

Crane Capacities:

<table>
<thead>
<tr>
<th>Crane Capacities</th>
<th>Crane Capacities</th>
</tr>
</thead>
<tbody>
<tr>
<td>36,000 lbs.</td>
<td>maximum</td>
</tr>
<tr>
<td>22,000 lbs. @</td>
<td>8 ft. boom Radius</td>
</tr>
<tr>
<td>16,550 lbs. @</td>
<td>12 ft. boom Radius</td>
</tr>
<tr>
<td>10,500 lbs. @</td>
<td>20 ft. boom Radius</td>
</tr>
<tr>
<td>5,500 lbs. @</td>
<td>35 ft. boom Radius</td>
</tr>
</tbody>
</table>

Note: Crane capacities may vary with boom length and attachments.

Frame:

- Box construction pedestal with turret mounted on shear type ball bearing and bulkhead fittings for crane operation.

Rotation:

- 270° non-continuous by means of planetary gear, hydraulic drive unit, and swing stops.

Boom:

- Three (3) section hydraulic telescoping boom, 16 ft. retracted to 38 ft. extended (maximum horizontal reach).

Winch:

- High performance planetary winch rated at 10,000 lbs. bare drum single line pull.

Controls:

- "RVC" (or equivalent) remote valve control group
- Anti-Two Block

Explosion-proof system that helps prevent cable damage by sensing position of winch cable and attachments with respect to sheave case.

Stabilizers:

- Rear hydraulic stabilizers, “A” type.

Physical Dimensions for Transportability:

- The crane must fold up and fit in the space provided on the crane trailer during transport.

Reel Pivot:

- A reel pivot cylinder that will pivot to either side of the unit will be installed on the unit.

Coiled Tubing Deployment Module:

- The WISE™ Unit should preferably deploy coiled tubing using the following combinations of coil tubing deployment modules and injector heads:

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Coil Tubing Deployment Module</th>
<th>Injector Head</th>
</tr>
</thead>
<tbody>
<tr>
<td>122&quot;-A</td>
<td>Modified HPT 122&quot; CT Reel Assembly</td>
<td>HydraRig 635</td>
</tr>
<tr>
<td>122&quot;-B</td>
<td>Modified HPT 122&quot; CT Reel Assembly</td>
<td>LSI</td>
</tr>
<tr>
<td>102&quot;-A</td>
<td>LS1 102&quot; CT Reel Assembly</td>
<td>HydraRig 635</td>
</tr>
<tr>
<td>102&quot;-B</td>
<td>LS1 102&quot; CT Reel Assembly</td>
<td>LSI</td>
</tr>
</tbody>
</table>

In the 122" A and B configurations the WISE™ Unit can:

- Spool 1 1/4" diameter CT @ 2500 psig operating pressure.
- Provide coiled tubing storage capacity for 1 1/4" Coiled Tubing (CT).
- Provide CT capacity by volume of:
- 21,500 feet of 1 1/4" tubing
- 15,500 feet of 1 1/2" tubing and
- 11,500 feet of 1 3/4" tubing.

In the 102" A and B configuration embodies the WISE™ Unit can:

- Spool 1 1/2" diameter 0.125" wall thickness CT @ 2500 psig operating pressure.
- Provide coiled tubing storage capacity for 1 1/2" Coiled Tubing (CT).
- Provide CT capacity by volume of:
- 16,000 feet of 1 1/4" tubing and
- 111,000 feet of 1 1/2" tubing.
- Provide coil tubing capacity by weight for carrying and deploying a total of 20,000 pounds of continuous coiled tubing.

Note: This embodiment of the WISE™ Unit’s CT length is limited by weight carrying capacity, not volume. Depending upon the wall thickness string length capacities will vary.

This embodiment of the WISE™ Unit supplies hydraulic fluid to an injector at an operator-controllable rate ranging from 0-85 gpm (inclusive) and at an operator-controllable pressure ranging from 0-3000 psig (inclusive).

Cryogenic Liquid Nitrogen Module

- The Cryogenic Liquid Nitrogen Module should preferably output up to 1,500 scfm gaseous nitrogen at 10,000 psig. However, note that overall integrated unit nitrogen capacities are below this peak due to horsepower limitations.

- The Cryogenic Liquid Nitrogen Module should preferably meet these output requirements in the onshore well servicing environment.

- The cryogenic liquid nitrogen module has two major components:

  - The cryogenic liquid nitrogen storage vessel
  - The nitrogen pump and vaporization component

Cryogenic Liquid Nitrogen Storage Vessel

- In the preferred embodiment the Cryogenic Liquid Nitrogen Storage Vessel module should preferably comprise a double layer vacuum insulated pressure vessel. This tank should preferably be provided with fill, suction vent, and pressure building manifolds and valves. The vessel capacity should preferably be approximately 1800 liquid gallons. This vessel will be removably attached to the upper deck on the land transport trailer.
Cryogenic Liquid Nitrogen Pump and Vaporization Component

The Cryogenic Liquid Nitrogen Pump and Vaporization Component should preferably draw cryogenic liquid nitrogen from the Cryogenic Liquid Nitrogen Storage vessel and force it through the vaporizer to produce gaseous nitrogen.

The Cryogenic Liquid Nitrogen Pump and Vaporization Component should preferably meet its output requirements in the offshore well servicing environment.

The preferred embodiment of the Cryogenic Liquid Nitrogen Pump and Vaporization Component comprises:

- 2"x1"x4x1/4" cryogenic centrifugal boost pump with rated high speed hydraulic motor to draw cryogenic liquid nitrogen from the storage vessel and pump it at low pressure (less than 100 psig) to a triplex injection pump.
- Triplex ICMP 100 type Cryogenic Nitrogen Positive displacement Pump, with rated high speed hydraulic motor, to develop pressure necessary to overcome the resistance to the fluid through the vaporizer.
- Pressure Oil Lubrication System for triplex pump crankcase.
- Liquid circulation type Liquid Nitrogen Vaporizer.

This component should preferably be packaged separate from other systems and the cryogenic liquid nitrogen storage vessel.

The Cryogenic Liquid Nitrogen Pump and Vaporization Component should interface with customer-furnished offshore cryogenic liquid nitrogen storage vessels without modification.

Marine Mobile Power Pack

The Marine Mobile Power Pack provides hydraulic power to concurrently operate the coil tubing and nitrogen modules at their maximum capabilities.

The Marine Mobile Power Pack should meet its power output requirement in the offshore well servicing environment.

The preferred embodiment of the Marine Mobile Power Pack should preferably be skid-mounted and comprise a crane frame, forklift guide tubes and a 4-point lift attachment for lifting slings, and one fall protection harness tie-off point incorporated into its crane frame.

The Marine Mobile Power Pack should preferably be no larger than 120" long x 96" wide x 102" high including the structural skid to allow 136" height clearance when loaded on a 48" tall truck trailer.

The Marine Mobile Power Pack should preferably weigh no more than 18,500 lbs maximum wet.

The preferred embodiment of the Marine Mobile Power Pack will have the following features:

- Caterpillar 3406C Diesel Engine with a double pump drive attached directly to the flywheel housing.
- Caterpillar matched heavy duty solders dripped radiator.
- Engine has onboard systems for shutdown in over-temperature and low oil pressure situations. Engine also has overspeed auto-shutdown protection and spark arrestor exhaust.
- Engine has mechanical lever for remote throttle position to control engine speed at power pack.
- Air Operated fuel shutdown system, and air operated emergency emergency shutdown (air shut-off). Emergency Kill system is failsafe (air signal to run, absent signal shut-down) type.
- Engine mounted Tachometer, oil pressure gauge, coolant temperature gauge and reservoir mounted air pressure gauge.
- 12 cfm air compressor system with 15 gallon reservoir.
- Air Starter System.
- Axial Piston high pressure open-loop pump for CT injector drive.
- Axial Piston high pressure open-loop pump for Nitrogen System drive.
- Double Vane pump for tubing reed and BOP functions.
- Single Gear pump for water/glycol circulation.
- Pump for well-servicing fluid with manifold designed to pump small volumes of acid (1500 gal), cement (10 bbl), and sand slurry (1500 lbs)
- Single fan powered air to oil heat exchanger mounted above fluid pump for hydraulic fluid cooling.
- Hydraulic Oil Reservoir capacity 250 gallons. Reservoir supplied with protected sight glass, returning fluid filters, and sampling port.
- Hydraulic Pump relief valves are piloted to a series of dump valves at a system start panel.
- Crash Frame provides an integrated access ladder to skid top.

Electric Generator

An Electric Generator provides electric power for distribution by the operator control module in onshore applications.

The preferred embodiment of the electric generator will:

- Use Diesel Fuel
- Meet a 6500 Watt Surge capacity
- Produce 5500 Watts continuous
- Start using a self-contained Electric Start system
- Output 120 VAC at 51 amps
- Output 120 VAC at TBD amps Duplicate Specification
- Run at least 12 hours on one tank of fuel
- fit within 36" length x 24" width x 24" height space on the onshore crane trailer
- weigh no more than 400 lbs

The Electric Generator should preferably meet these requirements in the onshore well servicing environment.

Coil Tubing Reel Carry Skid

A Coil Tubing Reel Carry Skid is used for transport of a Coil Tubing Reel Drum when the drum is removed from unit.

The Coil Tubing Reel Carry Skid should preferably hold the Coil Tubing Reel Drum in axle-horizontal position during:
onshore transport
offshore boat transport

The preferred embodiment of the Coil Tubing Reel Carry Skid should comprise forklift and crane sling provisions for moving between ground, truck, and boat in loaded and unloaded configurations, and one fall protection harness tie off point incorporated into its crush frame.

Coil Tubing Component Carry Skid

A Coil Tubing Component Carry Skid is used for transport of injector head, well control stack, and CT-specific tools when removed from a WISE™ Unit onshore transportation trailer.

The Coil Tubing Component Carry Skid should preferably hold the injector head, well control stack, and CT-specific tools during:

- onshore transport from onshore-to-offshore conversion location to dock
- offshore boat transport

The Coil Tubing Component Carry Skid should preferably have provisions for moving between ground, truck, and boat in loaded and unloaded configurations.

Hose Reel Skid

In the preferred embodiment, when the WISE™ Unit is converted to offshore use, a hose reel skid will provide the hydraulic fluid distribution between the modules. The onshore hydraulic fluid distribution will remain on the crane trailer.

The Hose Reel Skid should preferably carry all the WISE™ Unit’s interconnecting hoses needed for offshore use.

The Hose Reel Skid should preferably protect the WISE™ Unit’s interconnecting hoses from damage during transport from onshore to offshore.

The Hose Reel Skid should preferably have provisions for moving between ground, truck, and boat in loaded and unloaded configurations.

The Hose Reel Skid should preferably comprise:

- All hoses necessary to connect the Operator Control Module to the injector head and well control stack in 150-foot lengths.
- All hoses necessary to connect the Marine Mobile Power Pack to the Operator Control Module in 35-foot lengths.
- All hoses necessary to connect the Operator Control Module to the CT Reel in 35-foot lengths.

The hoses should preferably be labeled at each end with bands imprinted with text and by numbered stainless steel washers.

The Hose Reel Skid should preferably include 3 hose reels:
- One reel for OCM to injector head power hoses
- One reel for injector head control hoses
- One reel for BOP control hoses

The Hose Reel Skid should preferably include a hose rack for the marine mobile power pack-to-operator control module hoses.

An advantage of the present invention is that modularity enables change scenarios that can be quickly and cost effectively implemented:

1) Customer desires a change to WISE™ Unit-level requirements (addition, deletion, or change of capability) due to changing business environment

2) Vendor discovers that requirements cannot be met on schedule (i.e., component supplier lead times too great) and proposes alternatives that meet schedule.

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOP</td>
<td>Blowout Preventer</td>
</tr>
<tr>
<td>bbl</td>
<td>British Thermal Units-Hour</td>
</tr>
<tr>
<td>CT</td>
<td>Coiled tubing</td>
</tr>
<tr>
<td>gpm</td>
<td>gallons per minute</td>
</tr>
<tr>
<td>LSI Lamb Services, Inc</td>
<td></td>
</tr>
<tr>
<td>NEMA National Electrical Manufacturers Association</td>
<td></td>
</tr>
<tr>
<td>N2</td>
<td>Diatomic Nitrogen</td>
</tr>
<tr>
<td>pscf</td>
<td>Pounds per square inch gauge</td>
</tr>
<tr>
<td>scfm</td>
<td>Standard cubic feet per minute</td>
</tr>
<tr>
<td>SS</td>
<td>Stainless steel</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mean Time Between Failures</td>
</tr>
<tr>
<td>VDC</td>
<td>Volts DC</td>
</tr>
<tr>
<td>AC</td>
<td>Volts AC</td>
</tr>
</tbody>
</table>

Definitions

Availability—The days on which the WISE™ Unit is ready for transit between well-servicing sites and for well-servicing activities

Scarc—A hardware provision for a module or component coming later: must be consistent with the interface requirement

Hook—A software provision for programming coming later, such as the ability to expand functionality etc.

Depot Maintenance—maintenance done at a shop

Field Maintenance—maintenance done at a job site (other than inside the shop)

Line-replaceable subsystem—

Glycol—antifreeze used with water in heat transfer loops

Although the present invention has been described by reference to its preferred embodiment as is disclosed in the specification and drawings above, many more embodiments of the present invention are possible without departing from the invention. Thus, the scope of the invention should be limited only by the appended claims.

What is claimed is:

1. A single well servicing combination unit comprising:
   a hydraulic manifold removably connectable to the power-take-off of a power source to drive a plurality of hydraulic pumps and motors that control a plurality of well servicing modules that are removably mounted on said combination unit, said well servicing modules being interconnectable by plumbing.

2. The combination unit according to claim 1, wherein said power source comprises a power pack module.

3. The combination unit according to claim 2, wherein said power pack module is removably connected to said well servicing combination unit.
4. The combination unit according to claim 2, wherein said power pack module comprises a truck power pack.

5. The combination unit according to claim 2, wherein said power pack module comprises a marine mobile power pack.

6. The combination unit according to claim 2, wherein each module comprises a skid.

7. The combination unit according to claim 1, wherein said well servicing modules comprise:
   i. an operator control module;
   ii. a combination module;
   iii. a nitrogen module;
   said modules being interconnectable by plumbing.

8. The combination unit according to claim 7, wherein said combination module comprises a coil tubing module and an acid module.

9. The combination unit according to claim 8, wherein said coil tubing module comprises a coiled tubing reel and a coil tubing string.

10. The combination unit according to claim 9, wherein said coiled tubing reel ranges in diameter from about 102 inches to over 122 inches and said coil tubing string ranges in diameter from about 1.25 inches to about 2 inches.

11. The combination unit according to claim 7, wherein said combination module comprises a coil tubing module and a cement module.

12. The combination unit according to claim 11, wherein said coil tubing module comprises a coiled tubing reel and a coil tubing string.

13. The combination unit according to claim 12, wherein said coil tubing reel ranges in diameter from about 102 inches to over 122 inches and said coil tubing string ranges in diameter from about 1.25 inches to about 2 inches.

14. The combination unit according to claim 7, wherein said combination module comprises a cement module and an acid module.

15. The combination unit according to claim 7, wherein said nitrogen module comprises a tank of cryogenic nitrogen.

16. The combination unit according to claim 7, wherein said nitrogen module comprises a nitrogen generator that gathers nitrogen from the earth’s atmosphere and wherein said combination unit further comprises a compressor connectable by plumbing to said nitrogen generator.

17. The combination unit according to claim 7, wherein said nitrogen module comprises a tank of compressed nitrogen gas.

18. The combination unit according to claim 7, wherein said combination module comprises a sand fracturing tool.

19. The combination unit according to claim 1, wherein said well servicing modules comprise: an electric wireline apparatus comprising a tubing encapsulated wire conveyance medium suitable for electric wireline operations.

20. The combination unit according to claim 2, wherein said well servicing modules comprise: a combination module and an electric wireline apparatus comprising a tubing encapsulated wire conveyance medium suitable for electric wireline operations.

21. The combination unit according to claim 1, wherein said well servicing modules comprise: a wireline inspection unit and a coiled tubing unit.

22. The combination unit according to claim 4, wherein said combination unit comprises a crane trailer and said Truck Power Pack comprises a truck capable of towing said crane trailer.

23. The combination unit according to claim 4, wherein said well servicing modules are removably mounted on said crane trailer and comprise an Operator Control Module, a Coiled Tubing Deployment Module, an Injector Head Module, Well Control Stack Blow Out Preventer Module, and a Nitrogen Module.

24. The combination unit according to claim 23, wherein said Nitrogen Module comprises a Self Generating Nitrogen Module.

25. The combination unit according to claim 1, wherein each of said modules and components is designed to function in conjunction with a plurality of combinations of said well servicing modules.

26. The combination unit according to claim 1, wherein said modules may be custom arranged to allow the combination unit to fit in available space for a particular well servicing job.

27. The combination unit according to claim 1, further comprising a transportation module.

28. The combination unit according to claim 27, wherein said transportation module comprises a marine vessel.

29. The combination unit according to claim 28, further comprising a marine mobile power pack.

30. The combination unit according to claim 27, wherein said transportation module comprises an amphibious vessel.

31. The combination unit according to claim 30, further comprising a marine mobile power pack.

32. The combination unit according to claim 27, wherein said transportation module comprises a trailer.

33. The combination unit according to claim 30, further comprising a truck power pack.

34. The combination unit according to claim 27, wherein said transportation module comprises a skid.

35. The combination unit according to claim 1, wherein said well servicing units comprise: a high pressure pump and a blending tank; said high pressure pump and blending tank being interconnectable by plumbing.

36. The combination unit according to claim 35, further comprising a crane, said blending tank, high pressure pump and crane being interconnectable by plumbing.

37. The combination unit according to claim 1, wherein said well servicing modules comprise:
   i. a wireline inspection module;
   ii. a coiled tubing module;
   iii. a nitrogen module;
   iv. a unit pump module; and
   v. a blending tank module.

38. The combination unit according to claim 37 further comprising an acid pump module and an acid tank module that is connectable by plumbing to said blending tank module and said coil tubing module, wherein said hydraulic manifold is removably connectable to said power take-off of said power source to also drive hydraulic pumps and motors that control said acid pump module.

The combination unit according to claim 1, wherein said well servicing modules comprise: a coil tubing module and at least one other well servicing module.

39. The combination unit according to claim 1, wherein said well servicing modules comprise: a wireline inspection module; and at least one other well servicing module.

40. The combination unit according to claim 37, further comprising a combination nitrogen and high pressure pump.
module that is connectable by plumbing to said blending tank module and said coil tubing module, wherein said hydraulic manifold is removably connectable to the power-take-off of said power source to also drive hydraulic pumps and motors that control said combination nitrogen and high pressure pump module.

41. The combination unit according to claim 1, wherein said well servicing modules comprise: coiled tubing reel module for introducing well treatment fluid into a well; and an injector module that can advance said coiled tubing into a wellbore.

42. The combination unit according to claim 1, wherein said well servicing modules comprise a coiled tubing injector module and a crane module for picking up and lowering the coiled tubing injector of said coil tubing injector module.

43. The combination unit according to claim 1, further comprising an operator’s console module whereby said motors and pumps may be controlled by an operator.

44. The combination unit according to claim 1, wherein at least one of said modules is skid mounted.

45. The combination unit according to claim 1, wherein at least one of said modules is skid mounted.

46. A method of well servicing unit maintenance comprising keeping functional modules in inventory and replacing broken or unsatisfactory modules of a modular well servicing combination unit as desired.

47. A method of producing a well servicing unit comprising assembling standardized well servicing modules having standardized interfaces and connectors.

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