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Model FRAQ

FRAQ™

Fracing Water Treatment Systems

The FRAQ™ Series mobile treatment systems are designed to treat fracturing waters for removal of TSS, TDS, metals, O&G, COD and other contaminants in frac water applications.

Pan America Environmental **FRAQ™** systems are a versatile design utilizing a variety of technologies for reuse or disposal of frac flowback water and produced water from gas drilling allowing high loads of a wide variety of contaminants to be removed.

The **FRAQ™** systems are designed to react and float solids, oils and other materials via DAF technology.
The mobile system is based on a flexible, multi-stage chemical reaction technology that allows implementation of a variety of chemical process to accommodate changing conditions or change of site.

Hydro-Fracturing (Fracing) is the process of creating fissures or fractures in underground formations containing oil or gas which then allows oils and natural gas to flow.

These formations are typically shale and sand based. Under high pressures, sophisticated horizontally drilled wells are fractured to create the fissures and then the fissures are kept open for extraction of the oils & gases.

The process that produces these wells uses millions of gallons of water to create the well. This water most often must be treated to some degree for reuse or disposal.

Other materials and a variety of combinations and concentrations can be found from site to site as contaminants are dependent on formation and geology.

Bacteria occurs and can grow in downhole fissures, structures and equipment, so biocides are used to limit this.

Typical Flowback water contaminant breakdown:

- 99.5% water & sand
- Friction reducer
- Potassium chloride
- Surfactant (visc.increaser)
- Gelling agent
- pH adjusting agent
- Scale inhibitor
- Breaker aids
- Corrosion inhibitor
- Crosslinker
- Bubble breakers
- Buffers
- Cakes
- Celluloses
- Clay stabilizers
- Alcohols
- Biocides
- Acid
- Iron controller
- Bases

System Advantages:

- Treat a wide variety of water characteristics
- Process large water volumes
- Easy to deploy design
- Cost competitive
- Pre-treatment to R.O. systems
- Reduce demand on fresh water supply
- Provides water treatment in support of full recycle/reuse

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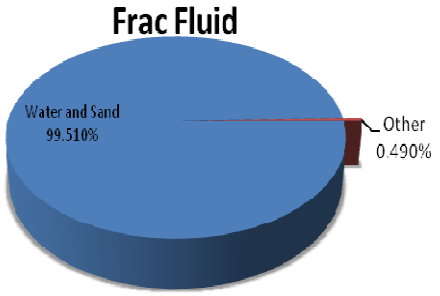
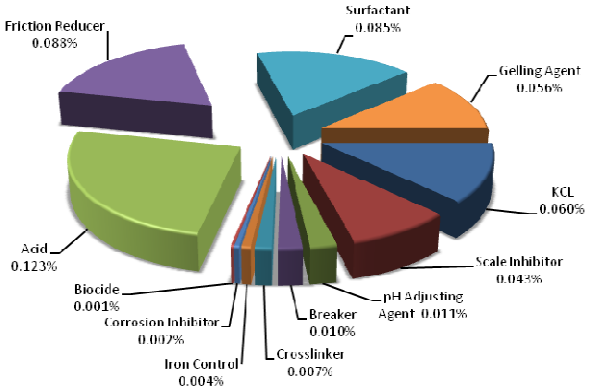
Water & Chemical Usage

The amount of water used in a fracturing operation varies from well to well and depends upon the well configuration (vertical or horizontal), the number of stages fractured, and the specific characteristics of the formation being fractured. In vertical wells with a single fractured stage it is not uncommon to use less than 50,000 gallons of water during a fracture job, while a multi interval fracture job in a horizontal well can use several million gallons of water.



Because the make-up of each fracturing fluid varies to meet the specific needs of each site or area, there is no one-size-fits-all formula for the types and volumes of each additive. In classifying fracturing fluids and their additives it is important to realize that service companies that provide these additives have developed compounds with similar functional properties to be used for the same or multiple purpose in different well environments. The difference between additive formulations may be as small as a change in concentration of a specific compound. The total percentage of additive in the fracture fluid is 0.5% - 2%.



Although the hydraulic fracturing industry may have a variety of compounds that can be used in their hydraulic fracturing fluid, any particular fracturing job may only use a few of the available additives. For example, the pie chart provided above represents the top 12 additives that might be found in the field, covering the range of possible chemicals that could be provided for a particular fracturing site.

The number of chemical additives used in a typical fracture treatment depends on the conditions of the specific well being fractured. The typical fracture fluid recipe will use very low concentrations of between 3 and 12 additive chemicals, depending on the characteristics of the water and the formation being fractured with each additive serving a specific purpose. For example, the predominant fluids currently being used for fracture treatments in the gas shale plays are water-based fracturing fluids mixed with friction-reducing additives (referred to as slickwater).

Adding friction reducers allows fracturing fluids and sand, or other solid materials called proppants, to be pumped to the target zone at a higher rate and reduced pressure than if water alone were used. In addition to friction reducers, other additives include: biocides to prevent microorganism growth and to reduce bio-fouling of the fractures; oxygen scavengers and other stabilizers to prevent corrosion of metal pipes; and acids that are used to remove drilling mud damage within the near-wellbore area.

Fluids are used to create the fractures in the formation and to carry a proppant agent (typically silica sand) which is deposited in the induced fractures to keep them from closing up.

Formations & Locations

Some of the well known formations are:

Formation	*States*
Bakkan	ND/SD/ID/MT/Saskatch, Can
Eagle Ford	Southern TX
Barnett / Ft. Worth Basin	Northern TX
Marcellus	NY/Appalachian Basin
Green River Formation	CO/UT/WY
Haynesville Shale	TX
Fayetteville	TX

Each formation produces gas, oil or both.

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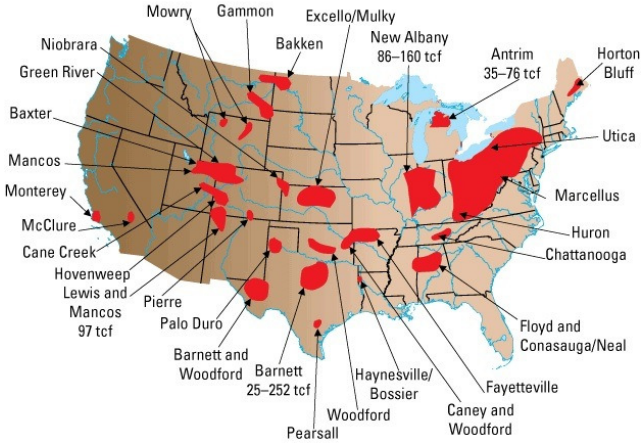
The following map shows formation locations.



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Treatment Process Design

Mobile treatment platform includes:

1. Oil Water Separator (if required)
- Removal of free & dispersed oils
- TSS reduction
- Reduce oil load on chemical processes
- May recover saleable oils

2. Chemical Treatment
- Flexible chemistry implementation
- Heavy metal reduction
- Suspended solids flocculation
- Mineral removal for scale reduction/elimination
- Sulfates, sulfides
- Organics
- Emulsion cracking capable
- Multi-stage reaction chambers
- Automatic metering pump system
- Variable speed agitators
- pH monitoring and controls
- Disinfection chemical metering

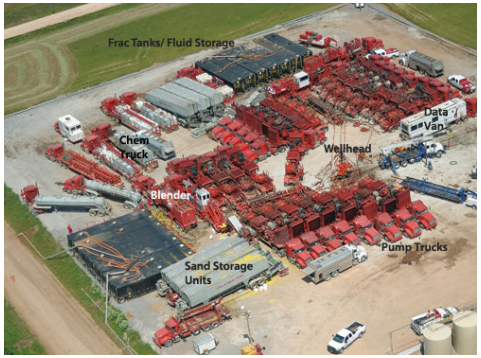
3. Dissolved Air Flotation
- Recycle saturation system for super-saturated water
- Auto-Q™ automatic equalization system
- Surface drag skimmer with adjustable timed on/off allowing dewatering of floating material prior to skimming.
- Hopper bottom for settleable solids collection
- Cover for control of VOCs
- Float pumpout system
- Sludge pumpout system

4. Master Control Panel (MCP)
- Nema 4X stainless or FRP enclosure
- Metallic switches & lights
- PLC driven system
- pH monitoring and pump control
- Programmable mixer VFDs

5. Additional Technologies
- Sand filtration
- Cartridge filtration
- Reverse Osmosis

Being that each well is different from other wells in their chemical/water makeup, flexibility and choice are key to a system design. All of these technologies can be provided together or individually to adapt to your project and equipment requirements.

Additional treatment equipment can be used after the FRAQ system to further treat the water as required for your reuse application for removal of TSS, TDS and chloride reduction.



Contaminants Removed
- Oils, fuels
- BTEX
- LNAPL
- DNAPL
- Dissolved solids
- Suspended solids
- Organics
- Heavy metals
- Sulfates, sulfides
- Bacteria
- Minerals

Flow Rates
The FRAQ systems can be provided in the following flow rate sizes:
- 50 GPM
- 100 GPM
- 250 GPM
- 500 GPM
- 800 GPM

Key Design Considerations
The following informational items are for consideration.

- Precipitation of minerals & metals will reduce TDS load
- Organics, nutrients & oxygen result in bacteria growth

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- Precipitation of barium sulfate tends to absorb radium, which may cause sludge to become hazardous.

Chlorine dioxide, if used may improve chemistry and performance with its capabilities:
- Breaks emulsions
- Is an oxidant
- Oxidizes reduced compounds, Fe, Mn, sulfides
- Kills bacteria
- Destroys friction reducers and other additives
- Does not react with ammonia and other organics

Post Treatment
Following the FRAQ system you can use the following equipment depending on your water use, reuse or disposal needs:
- Multi-media/sand filter (for fine TSS removal)
- Cartridge filter (as TSS polishing step prior to RO filter)
- R.O. filter for TDS/chloride removal (for reuse or other purposes)

Pilot System
A pilot system can be provided on a rental basis to facilitate field evaluation, testing, process determination and demonstration.

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FRAQ Treatment Train

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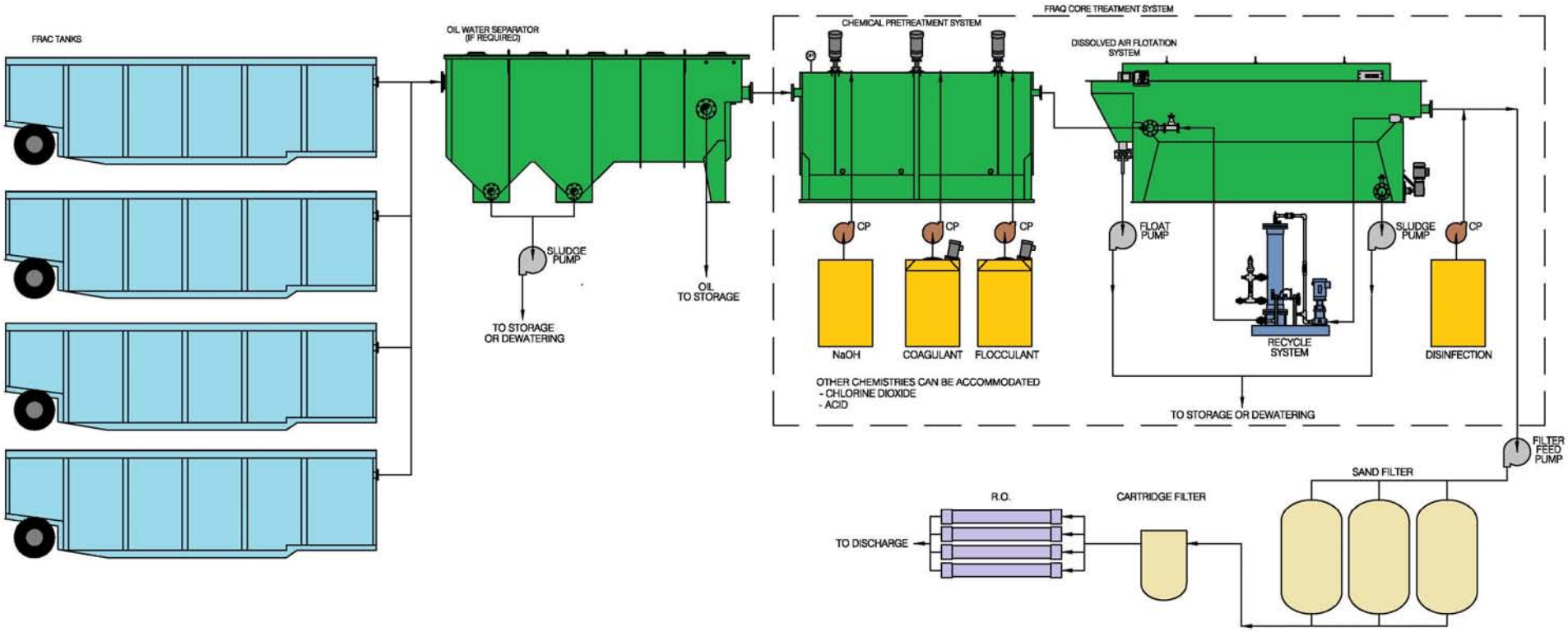

The representations given in this brochure are general in performance, design and nature and are subject to change based on application and site conditions. Design subject to change without notice.

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