ANNEX 2 – Diaphragm Units

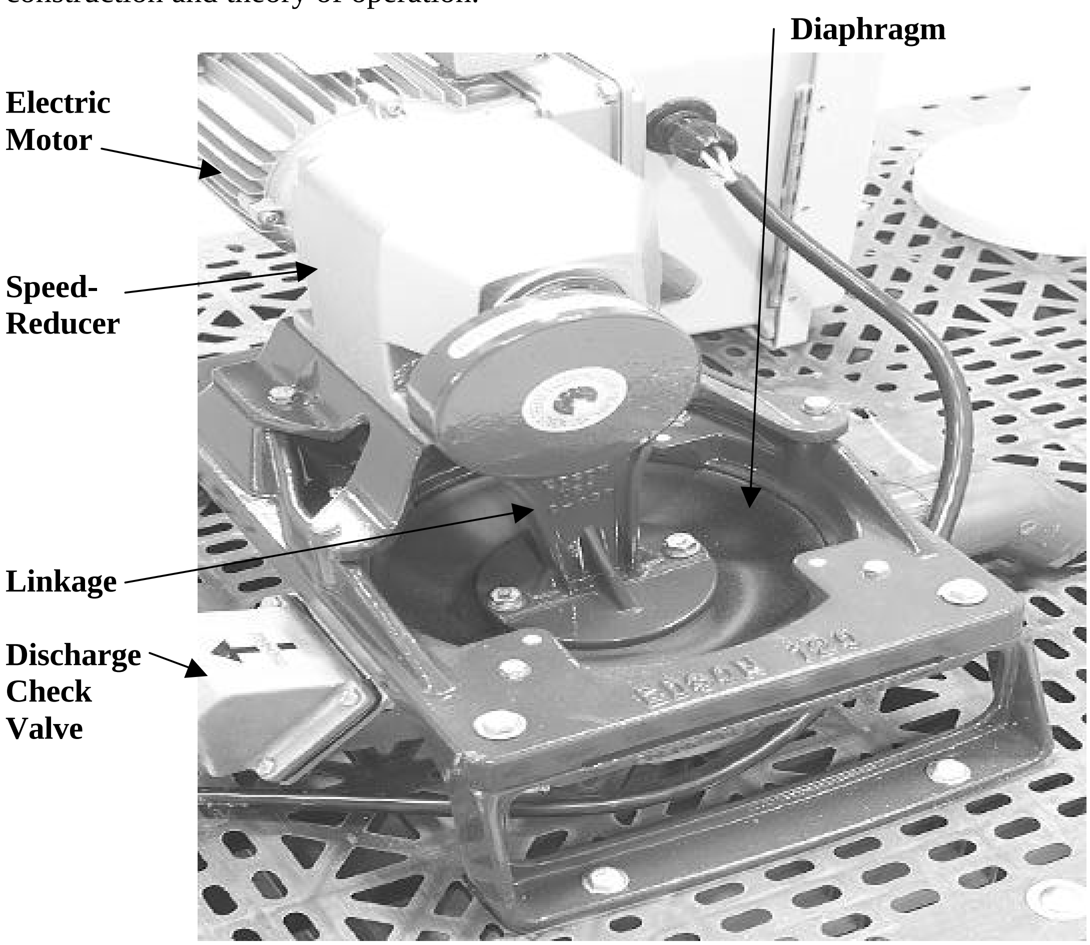
Annex 2.1 - General Information

The table below provides information on the three diaphragm pump-out units evaluated in this study.

Manufacturer	Model
Edson International	284EB-40
Exstar International	Sani-Station SS-100 Deluxe
Keco	PAH-175

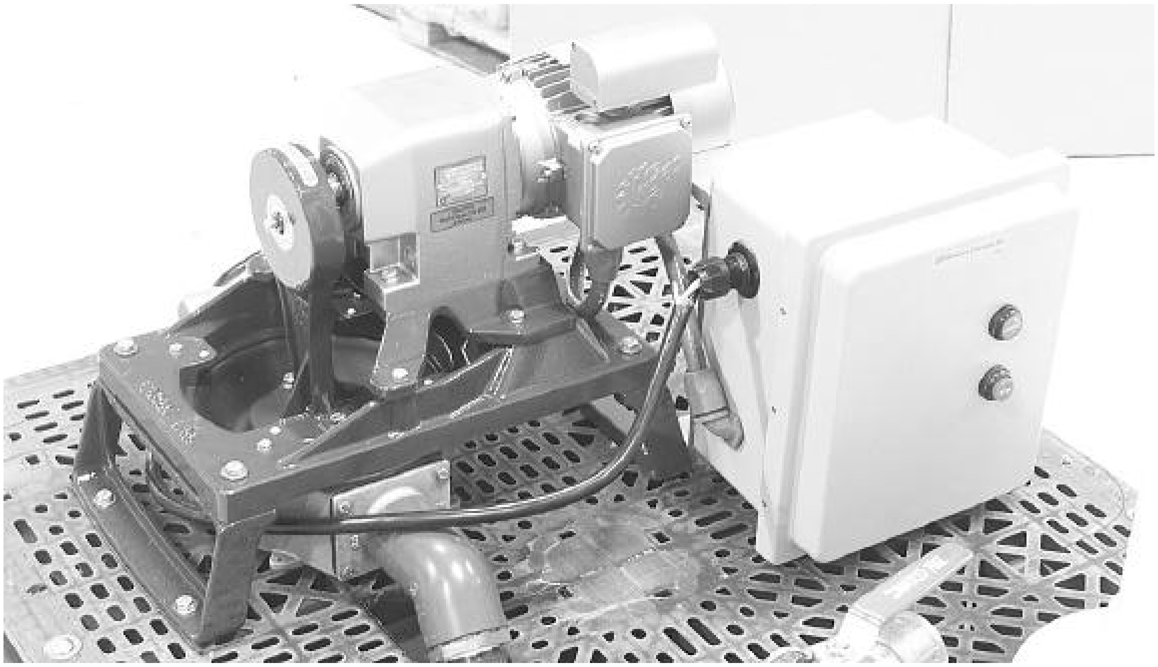
Theory of Operation – Diaphragm Pump-out

The photograph below is a close-up of the operating mechanism of the Edson International 284EB-40 Diaphragm Pump-Out unit. The pump operates by having an electric motor turn a speed-reducing mechanism that connects to a linkage that causes a reciprocating action on the diaphragm. The reciprocating action of the diaphragm causes suction in the pump internally during the up-stroke, and discharge pressure on the down-stroke. The direction of fluid flow through the pump is established by a set of check valves on the pump (i.e., a suction check valve on the inlet of the pump and a discharge check valve on the outlet of the pump). All three diaphragm pump-out units used this same basic construction and theory of operation.



Annex 2.2 – Manufacturer: Edson International
Model: 284EB-40 (Diaphragm)

Unit Photograph



Description of Pump-Out Unit

Serial Number: 28098

Construction: Marine Bronze Pump Body
Nitrile Diaphragm and Valves
Stainless Steel Hardware
Aluminum Frame
Inlet – 2" Male NPT
Discharge – 2" Male NPT
Molded Solid Fiberglass Enclosure

Rating of Electric Motor: ¾ Horsepower, 115 Volts, 8.4 Amps (as configured for testing)
Circuit breaker used in life-cycle testing set-up: 20 Amps
GFCI protection provided by a GFCI receptacle outlet

Rating of Speed Reducer: Ratio: 31.17; Maximum Torque: 1770 in-lbs

Summary of Life-Cycle Testing Performance

Special Note: Upon review of the proposed testing criteria for the diaphragm pumps, Edson International notified the SOBA test committee that the factory would not recommend the use of their diaphragm pump under such conditions. In the interest of being represented, Edson International did submit their diaphragm pump for testing.

The SOBA test committee would like to recognize Edson International for the forthright manner in which addressed this issue, and also for their willingness to submit their diaphragm unit for testing even though they recognized that the testing would exceed its recommended capabilities.

The Edson International 284EB-40 Pump-Out unit suffered two diaphragm failures during a period of 48.8 hours of operation in the life-cycle testing set-up (See *Summary of Repairs* below). The diaphragm failures occurred due to the large stresses that were generated on the diaphragm by the combination of the suction lift and discharge head that the unit was exposed to in the test set-up. After consultation with the manufacturer concerning these failures, Edson International chose to remove the unit from the study.

Summary of Repairs

Edson International
Model: 284EB-40

Repair Required	Run Time on Unit (hours)	Repair Parts Required	Cost of repair parts	Time required to receive parts (days)	Time required to make repair (hours)	Total Time Off-Line (days)
Replace diaphragm	36.5	diaphragm	$95.00	0 **Note 1**	1	1.1
Replace diaphragm	48.8	diaphragm	$95.00	**Note 2**	N/A	N/A

Note 1: Edson International provided a spare diaphragm, so the repair parts were on-hand.
Note 2: Edson International decided to remove the unit from the study. Another replacement diaphragm was not ordered.

Results of Environmental Testing

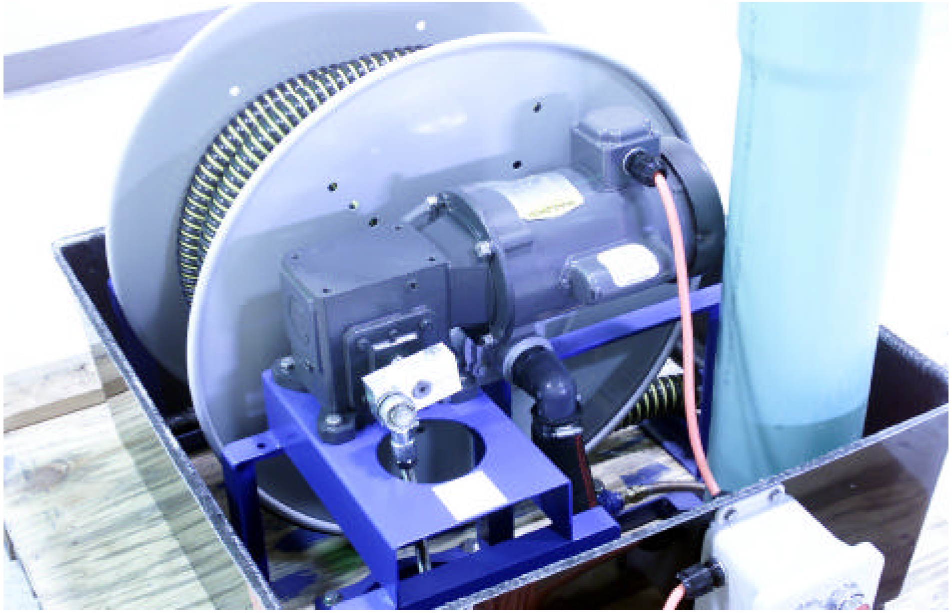
1. <u>Corrosion Resistance</u>: A sample of the Aluminum Frame was subjected to the Salt-Spray Exposure described in *Section 2.3*. The sample was found to have superior corrosion resistance.
2. <u>Ultraviolet Exposure Resistance</u>: A sample of the Molded Solid Fiberglass Enclosure for the unit was subjected to the Ultraviolet Exposure described in *Section 2.4*. The sample was found to have superior resistance to fading, cracking, and discoloration due to simulated exposure to sunlight and moisture.

Annex 2.3 – Manufacturer: Exstar International
Model: Sani-Station SS-100 Deluxe (Diaphragm)

Unit Photographs

External View

Internal View



Description of Pump-Out Unit

Construction: Cast Iron Pump Body (treated with rust inhibitor and painted)
Rubber Diaphragm (with cord reinforcement)
Neoprene Valves (with cord reinforcement)
Stainless Steel Hardware
Steel Frame (primed and painted)
Inlet – 2” Male NPT
Discharge – 2” Male NPT
Molded Solid Fiberglass Enclosure

Rating of Electric Motor: ½ Horsepower, 115 Volts, 7.4 Amps (as configured for testing)
Circuit breaker used in life-cycle testing set-up: 20 Amps
GFCI protection provided by a GFCI receptacle outlet

Rating of Speed Reducer: (Note: Electric motor operates at 1725 rpm):

1. Original Equipment: Horsepower @ 1750 rpm: 0.41
   Ratio: 30
   Output Torque: 328 in-lbs

2. Replacement: Maximum Input Horsepower @ 1750rpm: 0.55
   Ratio: 30
   Output Torque: 472 in-lbs

Summary of Life-Cycle Testing Performance

The Exstar International Sani-Station SS-100 Deluxe Pump-Out unit operated for 159.6 hours in the life-cycle testing set-up. During this time period, the unit suffered three failures (See *Summary of Repairs* on page 43). The failures occurred due to the large stresses that were generated on the unit by the combination of the suction lift and discharge head that the unit was exposed to in the test set-up. After consultation with the manufacturer concerning these failures, Exstar International chose to remove the unit from the study.

Summary of Repairs

Exstar International
Model: Sani-Station SS-100 Deluxe

Repair Required	Run Time on Unit (hours)	Repair Parts Required	Cost of repair parts	Time required to receive parts (days)	Time required to make repair (hours)	Total Time Off-Line (days)
Replace suction hose	47.3	Suction hose	$207.20	4	0.25	3 **Note 1**
Replace motor & speed reducer	136.0	Electric motor & speed reducer	$881.67	Speed reducer- 18 Motor- 17	2.0	56 **Note 2**
Replace pump shaft	159.6	Pump shaft	$13.00	7	1	40 **Note 3**
Speed reducer mounting bolts sheared off	Failure occurred on the first overnight run following pump shaft replacement. Exstar International removed unit from study – repair was not made.					

Note 1: Used replacement hose on hand from the Edson International diaphragm unit that had been removed from the study.
Note 2: Originally, just a speed reducer was ordered from Exstar International. When the speed reducer was replaced, the shaft on the electric motor was found to have significant wear at the keyway. A new electric motor was ordered from Exstar International and the electric motor was replaced in addition to the speed reducer. Delays encountered in the repair were not due to Exstar International.
Note 3: Delays encountered in the repair were not due to Exstar International.

Results of Environmental Testing:

1. <u>Corrosion Resistance</u>: A sample of the metal frame was subjected to the Salt-Spray Exposure described in *Section 2.3*. The sample was found to have inferior corrosion resistance. The sample displayed pronounced corrosion on bare metal surfaces of the sample. The painted surfaces of the metal sample exhibited good corrosion resistance.
2. <u>Ultraviolet Exposure Resistance</u>: A sample of the Molded Solid Fiberglass Enclosure for the unit was subjected to the Ultraviolet Exposure described in *Section 2.4*. The sample was found to have superior resistance to fading, cracking, and discoloration due to simulated exposure to sunlight and moisture.

Annex 2.4 – Manufacturer: Keco
Model: PAH-175 (Diaphragm)

Unit Photograph

External View

Internal View (Cover removed)

Description of Pump-Out Unit

Serial Number: 1220

Construction: Cast Iron Pump Body
Nitrile Diaphragm and Valves
Stainless Steel Hardware
Painted Steel Frame (zinc-based primer used for corrosion resistance)
Molded Solid Fiberglass Enclosure

Rating of Electric Motor: ¾ Horsepower, 230 Volts, 4.15 Amps (as configured for testing)

Circuit breaker used in life-cycle testing set-up: 20 Amps
GFCI protection provided by a GFCI circuit breaker

Rating of Speed Reducer: (Note: Electric motor operates at 1725 rpm):

1. Original Gearbox: Ratio: 31
   Horsepower @ 1725 rpm: 1.0
   Service Factor: 1.15

2. Replacement Gearbox: Ratio: 31
   Horsepower @ 1725 rpm: 1.75
   Service Factor: 1.15

Summary of Life-Cycle Testing Performance

1. The Keco Model PAH-175 as originally submitted failed during the initial test runs with water. The connecting pin on the speed reducer failed due to large stresses on the operating mechanism. A representative of Keco made a site visit to UL and modified the pump-out unit by installing a vacuum relief valve on the suction piping of the unit. This modification allowed a small amount of air to be introduced into the suction of the pump during operation and this reduced the differential pressure across the pump and reduced the stress on the operating mechanism of the pump.

2. The Keco Model PAH-175 (modified) operated for 834.7 hours in the life-cycle testing set-up. During this time period, the unit suffered four failures (See *Summary of Repairs* on page 46).

Summary of Repairs

Keco
Model: PAH-175 (modified)

Repair Required	Run Time on Unit (hours)	Repair Parts Required	Cost of repair parts	Time required to receive parts (days)	Time required to make repair (hours)	Total Time Off-Line (days)
Replace diaphragm	684.5	diaphragm	$19.00	6	0.5	6
Replace speed reducer	684.5	speed reducer	$250.00	1	0.75	7 **Note 1**
Replace discharge check valve	823.5	discharge check valve	$8.00	0 **Note 2**	0.25	1
Replace cracked 1.5" PVC Tee on suction piping	823.5	1.5" PVC Tee	$1.89	0 **Note 3**	0.75	1
Troubleshoot discharge piping leak and tighten discharge union	823.5	None	None	1	0.25	1

Note 1: Delays encountered in the repair were not due to Keco.
Note 2: Keco provided a replacement set of suction and discharge valves, so the repair parts were on-hand.
Note 3: Part purchased at local plumbing supply and was obtained on the same day as the failure.

Results of Environmental Testing

1. Corrosion Resistance: A sample of the metal frame was subjected to the Salt-Spray Exposure described in *Section 2.3*. The sample was found to have inferior corrosion resistance. The sample displayed pronounced corrosion on bare metal surfaces of the sample. The painted surfaces of the metal sample also exhibited corrosion under the surface of the paint.
2. Ultraviolet Exposure Resistance: A sample of the Molded Solid Fiberglass Enclosure for the unit was subjected to the Ultraviolet Exposure described in *Section 2.4*. The sample was found to have superior resistance to fading, cracking, and discoloration due to simulated exposure to sunlight and moisture.

Annex 2.5 – Conclusions regarding Diaphragm Pump-Out Units

1. The most common repairs for the three diaphragm pumps were:
    a. diaphragm replacement
    b. speed-reducer mechanism replacement

2. The Keco Model PAH-175 was the only diaphragm pump-out unit in this evaluation that utilized a vacuum relief valve on the pump suction. The vacuum relief valve allowed a small amount of air to be introduced into the suction of the pump during operation and this reduced the differential pressure across the pump and reduced the stress on the operating mechanism of the pump. The other two diaphragm pump-out manufacturers were consulted to see if this modification was available for their pump-out units. Neither Edson International nor Exstar International use a vacuum relief valve as a standard modification to their diaphragm systems to reduce operating stress.

3. The diaphragm pump-out units that did not have a vacuum relief valve installed (Edson International 284EB-40 and Exstar International Sani-Station SS-100 Deluxe) suffered failures of the diaphragm or operating mechanism due to excessive stresses during operation in the life-cycle testing set-up.

4. The Edson International 284EB-40 unit had a larger diaphragm (9 inches in diameter) than the other two diaphragm units (both had 7" diameter diaphragms). Because of the larger diaphragm, the forces exerted on the pumping mechanism of the Edson International unit were generally higher than the forces encountered in the other two units and, most probably, was a major factor in the two diaphragm failures in this unit during the initial phase of life-cycle testing.