CURRENT TO PRESSURE TRANSDUCERS
FOR THE ARGON & NITROGEN DEWARS

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8 - 25 - 88

D-ZERO ENGINEERING NOTE 3740.515-EN-176

APPROVED: _____

A handwritten signature in cursive script, appearing to read "Kelly Dixon", is written over a horizontal line.

IMPLEMENTATION:

A current to pressure (I/P) transducer will be used in the D-Zero piping system. The transducer is necessary to precisely control the control valve positioners located at the argon and nitrogen dewars. A 4-20 mA signal will come from the PLC function of the TI565. This electric signal must be converted by the transducer to a pneumatic signal of 3-15 psi which will position the actuator. By doing this, the valve can be opened or closed to any adjusted amount from the control room or a remote I/P controller. A total of 9 transducers will be used at the dewars. The nitrogen dewar will have 3 that are located outside and will have to be weatherproof. The argon dewar will have 6, located inside, that will have to be explosion proof or intrinsically safe.

DIAGRAM 1. I/P Transducer layout

INSTRUMENT OVERVIEW:

The transducer is an electropneumatic instrument that regulates an air supply pressure at 100 psi down to an output pressure which is directly proportional to a 2 wire current input (sometimes the current input comes along with voltage wire hook-up if not enough Vdc comes through the current lines). The transducer supply pressure is reduced by a supply valve to provide output pressure. In addition, some models incorporate a feedback system which adjusts the supply valve until the output feedback signal and input signal combine to produce the correct command signal. Typically, the transducer is used to signal a valve positioner. If it is used for direct loading of valve actuators or other large volumes, a volume booster relay is required that would increase the flow rate of the air to minimize time lags and the effects of leakage. The dewars already have positioners installed on the actuators, so no volume boosters will be necessary.

CRITERIA FOR APPLICATION:

1. The 3 transducers located at the nitrogen dewar will have to be weatherproof and endure temperature extremes.
2. The 6 transducers located at the argon dewar could encounter hazardous gases and must be explosion proof or else be intrinsically safe.
3. The microcomputer sends a 4-20 mA signal, 10 Vdc @ 20mA. If the transducer requires more than 10 Vdc @ 20 mA, then a power supply will be required.
4. The valve positioner requires a 3-15 psi input from the transducer.
5. A supply pressure is available at 100 psi.
6. An accuracy of better than 1% is desired

COMPANIES CONTACTED:

1. Fischer Company, Don Mueller 956-8020
2. Dalec Distributors, distributor of ACT products, 283-0300
3. Valtek, Dave Vivoli 629-3504
4. Rosemont, Roger 495-8383
5. BEC, Cal Miller 319-285-9008
Clawson Controls, local distributor, 381-0827
6. Rexnord Bellofram, Jim Pegg 513-434-9926
Carrier-Oehler Co., local distributor Ken Rude 815-455-6572
7. Moore Products, Keith Lynch 215-646-7400
8. Ohio Semitronics Inc., No Product
9. Omega, No Product
10. Robinson- Halpern, No product

SELECTION:

The lowest priced transducer was the ACT PXP2 by Dalec Distributor. It only cost \$136, but the price certainly reflected the quality. When a photo of the ACT PXP2 was presented, it showed no housing for the unit and the air line connections were plastic fittings. The ACT unit also requires 24 Vdc which means a power supply would have to be purchased. The lack of quality of the product prevents this product from further consideration. Fischer makes a type 546 transducer specifically designed for the Fischer positioners used. The Fischer transducer was the most expensive at \$577, but did not out-perform some of the lower cost models, so it too was not considered.

However, it should be observed that Fischer makes a transducer positioner combination for \$797 in stock or a discount price of \$666 if one is willing to wait 8 weeks. The Fischer positioner alone costs \$500, so a combination unit could cost as little as \$166 more.

Unfortunately, the positioners were already bought and installed, so they could not be returned or exchanged. In the future, it is advised that the transducer and positioner be purchased as a unit. Valtek also makes a combination positioner transducer for only \$630.

Valtek sells a transducer alone for \$470. Rosemont makes a transducer for the same price of \$470. The Rosemont transducer is more accurate and has more features, such as a regulator and filter, so it is the one that will be selected at that price level. Moore Products makes a weatherproof model for \$265 and an intrinsically safe model for \$315. Rexnord Bellofram makes an explosion proof model for \$365. BEC Products makes the most economical transducer to consider for weatherproof environments only at \$152. Five models will be compared in selecting the optimum transducer for this application. They are the following:

1. BEC #E275E-A1, weatherproof
2. Moore Products #GS771-16, weatherproof
3. Rexnord Bellofram #241-968-021, explosion proof
4. Rosemont #3311SS1A1B1F1, explosion proof
5. Moore Products #GS771F-16, explosion proof

The general specifications for these models can be found in **Appendix A**.

ADVANTAGES & DISADVANTAGES OF SELECTED I/P TRANSDUCERS:

BEC transducer: (weatherproof)

Advantages-

The BEC transducer offers the best price for the weather-proof model. The total price is less than half of the next competitor. The internal components of the weatherproof model are claimed to be the same as those in their \$490 explosion proof model. BEC claims that the extra cost for the explosion proof is in the housing only, which sounds a little excessive. It only needs a two wire

system for the input signal and the power supply, provided there is 24 Vdc @20 mA. The thickness of the housing wall is too thin to allow a conduit to be screwed into it for electrical wiring. A 7/8" hole for a conduit to slide into the housing does exist, to allow a nut and washer to box fit the conduit against the housing. It can be ordered with a female 1/8" Swagelock fitting for the pressure lines. It comes with a snap track for mounting. The supply pressure is too excessive for it, but a regulator can be purchased for only \$11.

Disadvantages:

The accuracy of the BEC is +1%, this is significantly greater than that of any of the other models. The transducer is sensitive to shock, so it has to be mounted on the wall away from vibration instead of near or on the control valve. The 1/4" pressure tubing will have to be reduced to adapt to the 1/8" compression fittings on the transducer. The required supply voltage is 24Vdc @ 20 mA. The microcomputer lines are only supplying 10 Vdc, so a power supply would have to be added to the system. The addition of the power supply means more electrical lines to be routed.

Moore transducers: (weatherproof, intrinsically safe)

Advantages:

Both the weatherproof model and the intrinsically safe model have an accuracy within 0.5%. The transducers are designed to be insensitive to shock and vibration. It only needs 5 Vdc supply voltage from the electrical lines, so no additional power supply is necessary. The weatherproof model can operate at

temperatures 20° below and 40° above the BEC model. The 1/4" supply and outlet lines are easily piped to the unit with no modifications. Accuracy can be upgraded to 0.25% of span for an additional \$85 for both the weatherproof and the intrinsically safe model.

Disadvantages:

The supply pressure is excessive for these transducers, so a regulator at \$102 has to be added to the cost. One regulator could be used for the three transducers at the nitrogen dewar, and one regulator could be used for the six transducers at the argon dewar. This means an additional \$34 each for the nitrogen dewar transducers and an additional \$17 each for the argon dewar transducers. Mounting is an additional \$23 each for pipe mounting or \$12 each for wall mounting. Pipe mounting is preferred. In addition the intrinsically safe model must be used with a \$50 barrier. The realistic cost for each transducer is \$322 for the weatherproof model and \$405 for the intrinsically safe model. For an increase in accuracy to 0.25% of span the cost is \$407 for the weatherproof model and \$490 for the intrinsically safe model.

Rexnord Bellofram transducer: (explosion proof)

Advantages:

The Rexnord Bellofram type 1001 transducer is the most economical explosion proof model, yet it has the characteristics of the most expensive models. This transducer can handle the 100 psi supply pressure without the need of a regulator. The accuracy of the model is 0.1% typical. It has closed loop feedback control

to minimize the effects of vibration, temperature, supply pressure, and mounting angle. The unit allows for span adjustment of ± 0.5 psi. A built-in volume booster provides a flow of 12 SCFM for a supply pressure of 100 psi. The greater the flow the faster the response time of the unit.

Disadvantages:

The feedback system and extra electronic components means a more complex design, which means a greater chance of failure.

Rosemont transducer: (explosion proof)

Advantages:

The Rosemont transducer is the top of the line of the transducers compared. The major mechanical and electrical components have been incorporated into a single field replaceable module. This means that it does not have to be removed from its mounting to facilitate troubleshooting and servicing. The model uses an electronic feedback control network. The model comes with a filter/regulator that mounts directly onto the transducer. It has excellent vibration stability.

Disadvantages:

The feedback system means a more complicated system, and therefore, a greater chance of failure.

ANALYSIS:

The Rexnord Bellofram transducer has a guaranteed accuracy two times better than the Rosemont transducer. The Rexnord Bellofram model is also better than the Rosemont when looking at temperature effects, output flow rate (proportional to response time), and air consumption. The Rosemont is slightly better for vibration effect. In looking at these two, since the Rosemont shows no significant gain and might even be worse, the savings of \$100 per transducer makes the Rexnord Bellofram the better choice. Moore's intrinsically safe model does not exceed the Rexnord Bellofram model in any specification, and it also costs more. Therefore, for the six transducers in the argon dewar, where explosive gas occurrences are possible, the optimal transducer would be the Rexford Bellofram type 1001 explosion proof.

For a weatherproof model the BEC transducer is the lowest price. However, the addition of a regulator, power supply, and necessary modifications to the pressure lines and electrical lines add to this price. The accuracy is the worst of all the models. The unit cannot be mounted near the valve due to shock sensitivity, which means longer lines. Although this model can be made to work, it is not designed for this application, making it a hesitant choice. Moore's weatherproof model is designed for this application, and it will work with only the addition of a regulator. The quality of the model and reputation of Moore products makes it a better and safer choice than the BEC model.

The final selection is whether to use two separate models, the Moore model for the weatherproof area and the Rexnord Bellofram for the explosion proof area, or the Rexnord Bellofram model throughout. Ideally, one model would be best to allow for interchangeability and minimize the supply of spare parts. The Moore product saves \$43 for each of the three transducers at the nitrogen dewar, but its accuracy is only half as good as the Rexnord Bellofram. To increase the Moore model to the same accuracy as the Rexnord Bellofram would cost an additional \$85 for each transducer. The Rexnord Bellofram transducer outperforms the Moore model in

all other specifications, especially in temperature effects. The total cost for three Moore models and six Rexford Bellofram models is \$3,156. The total cost of nine Rexnord Bellofram models is 3,285. The 4% increase in cost for the use of one model is justified by the possibilities of interchangeability, minimal supply parts, and superior quality of the Rexnord Bellofram model. The Rexnord Bellofram type 1001 I/P transducer is recommend for use at the control valves at both dewars. **Appendix B** shows the principal of operation of this model.

APPEDIX A

SPECIFICATIONS OF I/P TRANSDUCERS

**CURRENT TO PNEUMATIC TRANSDUCER FOR
DEWAR ACTUATORS ON CONTROL VALVES**

CRITERIA:
 3-15 psi output
 7.2 Vdc source
 100 psi supply
 4-20 mA input supplied at 7.2V
 3 weatherproof N2 dewar
 6 explosion proof Argon dewar
 9 total

COMPANY NAME & CONTACT
 BEC
 Cal Miller (319-285-9008)
Local distributor & contact
 Clawson Controls (Barrington,IL)
 Mr. Clawson (381-0827)

COMPANY NAME & CONTACT
 Rexnord Bellofram
 Jim Pegg (513-434-9926)
Local distributor & contact
 Carrier-Oehler Co. (339-8200)
 KEN RUDE (815-455-6572)

MODEL NUMBER & DESIGN	#E275W-A1 weather proof	#241-968-021 explosion proof
PRICE	\$152 weather	\$365
ADDED COSTS	\$11 regulator	Non required
TOTAL COST	\$163 weatherproof	\$365 explosion proof
DELIVERY TIME	3 weeks	7 weeks
WARRANTY	1 year	1 year
FEEDBACK SYSTEM	No	Yes
SUPPLY VOLTAGE	24 Vdc @ 20 mA	9 Vdc @ 20mA
MOUNTING	Snap Track	Universal mount
CONTROL INPUT	4-20 mA, 2-wire loop	4-20 mA, 2 or 3 wire loop
INPUT IMPEDANCE	600 ohms	6 kohm minimum, 3-wire
CONTROL OUTPUT	3 - 15 psig	3-15 psig
AIR SUPPLY	20 psig minimum, 30 psig max	18 psig minimum, 100 psig maximum
AIR CONSUMPTION	.008 SCFM Compressor sizing	0.07 SCFM
AIR CAPACITY	3.5 SCFM	12 SCFM at 100 psi
OPERATING TEMPERATURE	-20° to 140° F	-20° - 160° F
STORAGE TEMPERATURE	-40° to 160° F	-40° - 180° F
TEMPERATURE EFFECT	No information	≤0.02%/°F, zero and span effects combined
SUPPLY PRESSURE EFFECT	No information	Negligible
VIBRATION SENSITIVE	Yes	No
HUMIDITY	5 to 95% R.H. non-condensing	No information
ACCURACY	±1%	±0.25% span guaranteed, ±0.10% typical
LINEARITY	±1% Full Scale	No information
HYSTERESIS	0.75% Full Scale	0.10% of span maximum
REPEATABILITY	No information	0.10% of span
RESPONSE TIME	0.75% of input signal full scale	No information
DIMENSIONS	3" x 3-7/8" x 5-9/16"	4.10" x 3.28" x 3.5"
ADJUSTMENTS	None required	±0.5 psig adjustment of Zero and Span
PORT SIZES & FITTING	1/8" FPT(pneumatic)	1/4" NPT (pneumatic)
	7/8" Hole (electrical)	1/2" NPT (electrical)

**CURRENT TO PNEUMATIC TRANSDUCER FOR
DEWAR ACTUATORS ON CONTROL VALVES**

CRITERIA:

3-15 psi output
7.2 Vdc source
100 psi supply
4-20 mA input supplied at 7.2V
3 weatherproof N2 dewar
6 explosion proof Argon dewar
9 total

COMPANY NAME & CONTACT

ROSEMONT

Roger Kelm (495-8383)

Local distributor & contact

Same

COMPANY NAME & CONTACT

MOORE

Mike Van Beek (790-3550)

Local distributor & contact

Same

MODEL NUMBER & DESIGN	#3311SS1A1B1 Explosion proof	GS771-16 weatherproof GS771F-16 intrinsically safe
PRICE	425 without regulator	GS77-16 \$265 weatherproof GS77F-16 \$315 explosion proof
ADDED COSTS	\$45 regulator/filter add F1 to end of model number	\$102 for #GS40-30 regulator \$23 mounting, \$50 safety barrier
TOTAL COST	\$470	GS771-71 \$322 GS77-16 \$405
DELIVERY TIME	10-12 weeks	3-5 weeks
WARRANTY	1 year	1 year
FEEDBACK SYSTEM	Yes	No
SUPPLY VOLTAGE	7.2 Vdc	5 Vdc
MOUNTING	Universal bracket	\$23 pipe mount, \$12 wall mount, each
CONTROL INPUT	4-20 mA, 2- wire	4-20 mA, 2 wire
INPUT IMPEDANCE	No Information	185 ohms
CONTROL OUTPUT	3-15 psi	3-15 psi
AIR SUPPLY	18-24 psi	30 psi
AIR CONSUMPTION	0.2 SCFM at 20 psi supply	0.16 SCFM at 20 psi supply
AIR CAPACITY	4.0 SCFM at 20 psi supply	No information
OPERATING TEMPERATURE	-40 to 185° F	-40 to 180° F
STORAGE TEMPERATURE	-40 to 200° F	No information
TEMPERATURE EFFECT	±.2% + 0.03%/°F of span, typical	0.4%/°F of span
SUPPLY PRESSURE EFFECT	Negligible	less than 1% of span
VIBRATION SENSITIVE	No	No
HUMIDITY	0-100% condensing RH	No information
ACCURACY	±0.25% of span, typical	±0.25% of span
LINEARITY	included in accuracy	included in accuracy
HYSTERESIS	included in accuracy	included in accuracy
REPEATABILITY	included in accuracy	0.2% of span
RESPONSE TIME	No information	0.025% of span
DIMENSIONS	6.15" x 4.38" x 4.38"	5" x 7-11/32" x 3-15/32"
ADJUSTMENTS	No information	Zero offset +40% and -20% of span
PORT SIZES & FITTING	1/4 18 NPT (pneumatic)	1/4" NPT (pneumatic)
	1/2-14 NPT (electrical)	1/2" NPT (electrical)

APPENDIX B

PRINCIPLE OF OPERATION OF REXNORD BELLOFRAM I/P TRANSDUCER

APPENDIX B: Principle of operation of the Rexnord Bellofram type1001 I/P transducer:
(refer to figure B1)

Supply pressure is reduced by the supply valve to provide output pressure. In addition, output pressure is internally routed to a precision temperature compensated piezoresistive pressure sensor and an externally removable orifice which provides a reduced pilot pressure to a chamber

Figure B1: cross sectional view of Rexnord Bellofram type 1001 I/P transducer

containing a servo diaphragm and nozzle. Pilot pressure is controlled by modulating the gap between the face of the nozzle and the adjacent flapper. The flapper is configured to reduce the effect of vibration. The flapper serves as a control link between electrical input and pressure output as follows:

- The input current (I/P) is a normalized control signal directly proportional to the pressure output.
- Simultaneously, the output of the pressure sensor is amplified and conditioned to produce a feedback signal.
- The sum of the control signal and the feedback signal produce a command signal which is delivered as a DC current to the coil of an electromagnet.
- As coil current increases, increasing magnetic force is applied to the flapper which rotates about its taut band suspension so as to restrict nozzle bleed and thus increase pilot pressure.
- Increased pilot pressure applied to the servo diaphragm directly causes opening of the supply valve and an increase in the output pressure until the output feedback signal and control signal combine to produce the correct command signal.