CAPITULO 6. APLICACION. CONTROL DE TEMPERATURA EN UNA ZONA DE FUNDICION MEDIANTE EL CONTROL DE FLUJO DE COMBUSTIBLE Y COMBURENTE.

6.- APLICACION. CONTROL DE TEMPERATURA EN UNA ZONA DE FUNDICION MEDIANTE EL CONTROL DE FLUJO DE COMBUSTIBLE Y COMBURENTE.

Los conceptos discutidos en los capitulos anteriores,deberán ser utilizados como apoyo cuando se requiere diseñar y más adelante especificar a detalle los componentes de los sistemas de control o la instrumentación de una fábrica, el ejemplo que se presentará será real, se especificarán a detalle los componentes, pero sin profundizar en modelos de operación ni características del horno a discutir por razones de confidencialidad, además el diseño de un horno, por su grado de dificultad sería tema de otro trabajo.

6.1 ESPECIFICACIONES BASICAS DE DISEÑO.

Se desea especificar las necesidades de una sección de fundición con las siguientes características:

Se requiere fundir 1320 Toneladas/semana de materia prima (Arena Ceramica).

Eficiencia de fundición	120 Termas/Tonelada.
No. de Puertos de Combustion	4
No. de Quemadores/ Puerto	2
Control de Combustible	Combustoleo No. 6.
Control de Comburente	Aire de Combustión
Relación Aire - Combustoleo	8000 a 12000 - 1
Atomización de Combustoleo por medio de Aire	Relacion 280 - 1
Control de Temperatura de Combustoleo	Rango 0 - 150 °C
Control de Presion de Aire de Atomización	Rango 0 - 10 Kg/cm^2
Medición de Temperaturas en 12 Pos. Techo	Rango 1200-1450 °C
Medición de Temperaturas en 12 Pos. Piso	Rango 1000-1400 °C
Medición de Temperaturas en 8 Pos. Laterales 4 Lado Izquierdo y 4 Lado Derecho	Rango 800-1300 °C.

El sistema deberá ser capaz de registrar los valores promedios de las Temperaturas, Flujos de Combustoleo, Aire de Combustión y Aire de Atomización, y generar Reportes con promedios horarios cada fin de turno (8 hrs).

El Aire de Combustión debe controlarse automáticamente en relación con el combustoleo, de tal manera que el operador fije la relación deseada Combustoleo-Aire de Combustión y sólo ajuste el punto de referencia (Set Point) del Combustoleo y el Aire lo siga por relación automática.

El aire de atomización se controlará automáticamente, y estará relacionado con el flujo de combustoleo para atomizarlo en relación aproximada de 280 a 1 en volumen,ajustable por el operador,y si cae su presion abajo de 3 Kg/cm^2 por protección del equipo deben cerrar las válvulas de combustoleo. En el alcance de este trabajo, se considera el Horno ya diseñado.

6.2 ESPECIFICACIONES DETALLADAS DEL SISTEMA DE CONTROL Y SU SELECCION.

La zona de fundición a controlar es una parte del proceso total, el cual consta de varias zonas que interactúan entre si, cada una de ellas maneja de 10 a 30 lazos de control y decenas de termopares, tambien utilizan estrategias de control para tomar decisiones dependiendo del estado de ciertos eventos. Asi que el total manejado seria del orden de 140 lazos de control y 230 termopares, además de decenas de entradas analógicas (variables solo medidas) entradas digitales (señales de relevación, interruptores límite, etc) y salidas digitales (señales a relevadores, y dispositivos para arranque y paro de motores, lámparas indicadoras,etc).

Al tener que operar decenas de lazos de control, el operador puede perder la visión total en un momento determinado y alguna o algunas variables podrían salirse de control, realmente es muy dificil para una persona no perder detalle de la operación de mas de 100 controladores individuales, se requiere llevar registro de tendencias de las variables mas críticas, al menos 90 de ellas consideradas las más relevantes, esto se sugiere hacer en disco flexible y por mes, de tal manera que en un solo disco de 5 1/2 " o 3 1/4 " se lleve este registro así,sí en un momento determinado se requiere analizar la información de cualquier dia del año, de las cualesquiera 90 variables, sólo se recurre al disco del mes específico y se puede analizar la o las variables requeridas.

En la actualidad se está enfatizando en la operación eficiente y segura de las fábricas, por lo que es muy importante que el Control del Proceso sea confiable, el elevado costo de los recursos materiales y el enfasis en la protección de los seres humanos que de alguna forma están relacionados con el Proceso, ya sea por operación, mantenimiento, o simplemente por vivir en la vecindad, lleva a que la selección del Sistema de Control sea una etapa crítica del Diseño Total del Proceso, las experiencias actuales en la industria están demostrando que para el control de procesos de este grado de complejidad, la opción más confiable es el Control Computarizado Jerárquico. Por lo que, en el presente trabajo se considerará que el Control es un Sistema Computarizado Jerárquico.

Despues de decidir el Sistema Jerárquico como el control más adecuado para nuestro proceso (apoyado en los argumentos anteriores), el siguiente paso es identificar las necesidades, y en base a ellas establecer la arquitectura del sistema propuesto.

6.2.1 CALCULO DE CONSUMO DE ENERGETICOS.

Si la necesidad es fundir 1320 Toneladas/semana, a 120 Termas/Tonelada, el proceso requiere 158,400 Termas/semana.

Se requieren 15,840 MegaBTU's/sem. Ya que 1 Terma = 0.1 MBTU

Otra especificación básica del proceso, es que tiene 4 Puertos de Combustión con 2 Quemadores/Puerto, o sea un total de 8 Quemadores, por lo que cada quemador deberá ser capaz de suministrar (15,840/8) (MBTU/sem) = 1,980 MBTU/sem = 1,980/(7 x 24)

Capacidad de c/quemador = 11.7857 MBTU/Hr.

Se requiere entonces de quemadores con capacidad mínima de 11.8 MBTU/Hr , preferentemente de 14.63 MBTU/Hr , para tener un margen del 24% arriba de la capacidad requerida.

Considerando que la capacidad calorífica del Combustoleo es de 0.138 MBTU/Galon, se requiere en cada quemador un flujo de:

(14.63 MBTU/Hr)/(0.138) = 106 Gal/Hr = 401 Litros/Hr.

El Proceso entonces necesita 8 Quemadores de 14.63 MBTU/Hr. Y se requieren 8 Lazos de Control PID para flujo de Combustoleo #6 en un rango de 0 a 400 L/Hr.

8 Lazos de control similares para flujo de aire de atomización en relación 280 a 1 , o sea 112,000 L/Hr = 112 M^3/Hr. a 6 Kg/cm^2 absolutos (85 psia).

Asimismo se utilizará de comburente aire, en una relación variable de 8,000 a 12,000 a 1 , consideraremos la máxima relación de 12,000 a 1 y tenemos un rango de 4,800,000 L/Hr = 4,800 M^3/Hr, por lo que necesitamos 8 Lazos de Control de Aire de Combustión.

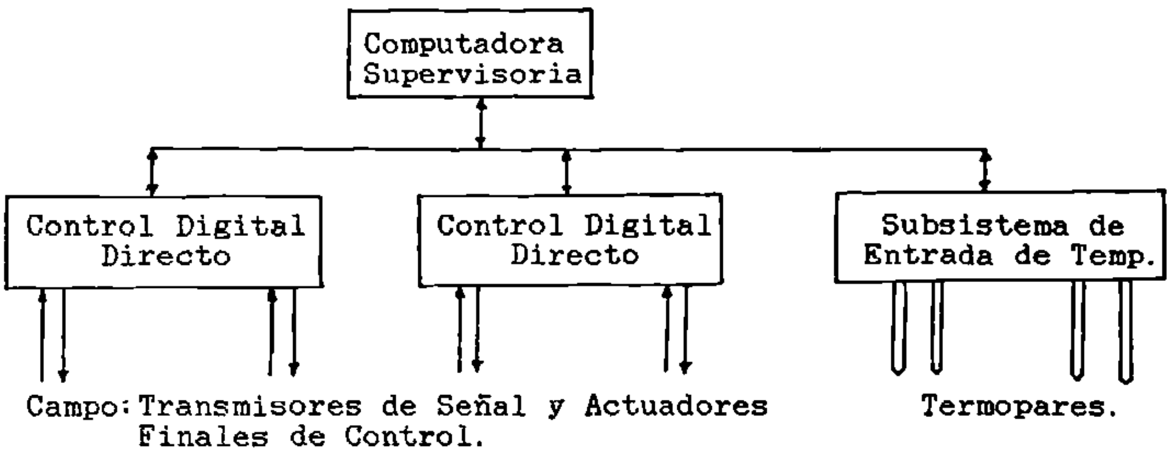
Por lo tanto agregando a estos, el Lazo de Control de Temperatura del Combustoleo, y el Lazo de Control de Presión de Aire de Atomización, se requiere para este Proceso de 26 Lazos de Control PID, 32 Indicaciones de Temperatura, además de señales digitales de entrada y salida para energizar bombas, motores,etc.

6.2.2 ARQUITECTURA PROPUESTA PARA EL SISTEMA.

Como ya se mencionó al inicio del capitulo se decidió instalar un Sistema de Control Computarizado Jerárquico.

Ya que el equipo de campo se encuentra retirado del Cuarto de Control, es muy conveniente que las computadoras de control digital directo y transmisores, se localicen en el sitio y que su comunicación a la computadora supervisoria sea por cable coaxial, de esta manera evitamos, que multitud de cables sean enviados de campo a cuarto de control.

Se establece la siguiente arquitectura de control:



Una vez identificadas las necesidades del proceso y definida la arquitectura del sistema, debemos seleccionar los equipos que conformaran el sistema de control.

El Ingeniero que toma esta decisión, debe basarse a mi manera de pensar en 4 puntos que son:

1.- Satisfacer las necesidades del Proceso. Esto significa, que el equipo propuesto cumpla con los requerimientos de diseño y arquitectura propuestos para el sistema.

2.- Opciones de crecimiento a futuro. Si el proceso crece y requiero incrementar las operaciones, hasta donde me limita o me permite el equipo propuesto.

3.- Permanencia de la Compañia Proveedora en el Mercado. Que tantos años tiene de experiencia en el Mercado, Capacidad de Operaciones incluyendo Servicio Especializado en Mantenimiento, Ingeniería de Sistemas, Configuración, Instalación, Refacciones, etc, en su Pais de origen, en el nuestro, y en nuestra localidad.

4. Costo del Equipo de Control. Se debe tomar en cuenta el Costo de las diferentes alternativas para finalizar el analisis. Este punto aunque importante no es definitivo ya que antes se deben cumplir los 3 puntos anteriores.

6.2.3 SELECCION DE EQUIPO DE CONTROL JERARQUICO.

En el caso que se analiza, el listado de especificaciones detalladas de diseño, (primer paso) lo cumplen ampliamente varios proveedores como son General Eléctric, Honeywell, Leeds & Northrup, Foxboro, y otros fabricantes mas pequeños como Research Inc, y Warren Inc. Todos ellos admiten opciones de crecimiento muy amplias, hasta varios cientos de lazos de control y cientos de entradas y salidas analógicas y digitales. (Punto No.2).

El Punto No.3 permanencia de la Cia. Proveedora, Honeywell resulto ser la mas confiable y segura de las opciones analizadas, demostró tener la mayor cantidad de especialistas en México y en la Zona Local y una Estructura de Ingeniería y Configuración muy fuerte. Esto le permite al cliente la tranquilidad de saber que en cualquier problema que se presente, contará con personal calificado para que le soporte y con existencia de refacciones.

Finalmente en el punto 4 aunque se vieron diferencias de precio en las marcas analizadas estas no son tan relevantes, como para inclinar la decisión hacia un lado u otro, y creo que en este caso influyó considerablemente la experiencia tenida en el pasado con la marca Honeywell, y la poderosa extructura de apoyo y soporte tanto local, como nacional e internacional. Cabe mencionar en justicia que actualmente otras compañias como Leeds & Northrup y Foxboro estan presentando equipos de muy alta tecnología y estan apoyando el soporte a nivel nacional por lo que creo que en un futuro próximo, estarán compitiendo muy fuertemente con Honeywell por el mercado nacional del control de procesos por medio de sistemas computarizados jerárquicos.

El Sistema de Control seleccionado para este proyecto es el Sistema Multifuncional, que forma parte del Sistema Integral de Control Jerárquico TDC-3000 Honeywell. Puede ser instalado a lo largo del proceso en forma distribuida, y de esos lugares puede conectarse a la computadora supervisoria que se encuentra en el cuarto de control, esto se hace por medio de un transportador de datos (bus), que es simplemente un cable coaxial, esto permite al operador acceso a cualquier información del proceso.

La arquitectura del Sistema propuesto está compuesta por el siguiente equipo:

Controladores Multifuncionales (MC). Que son realmente Computadoras de Control Digital Directo (CDD).

Unidades de Interfase de Proceso de Baja Energia (LEPIU). (Para señales de Termopares).

Estaciones de Operador (EOS). Computadora de mayor nivel o jerarquía que se comunica con los Controladores, y las Interfases de Proceso para el manejo de información a un nivel mas alto, además de tener la capacidad de tomar decisiones de control sobre los controladores multifuncionales, modificando su referencia.

El control lo efectúan los Controladores Multifuncionales que se encuentran distribuidos en la planta, realizando el continuo procesamiento de los lazos de control. Los Controladores cuentan con la electrónica necesaria para recibir entradas analógicas, digitales y de contadores de los dispositivos de campo, realizan los cálculos de control de acuerdo al algorítmo y secuencia de control asignado,y proveen las salidas digitales y analógicas resultantes a los dispositivos de campo, cada controlador multifuncional puede manejar hasta 16 lazos de control, pero sólo 8 salidas analógicas, pero en cada controlador se pueden agregar 1 o 2 ensambles auxiliares cada uno acepta de 1 a 8 tarjetas de entradas y salidas analógicas o digitales (apendice, boletin Honeywell BC-03-01 pag 9).

Adicionalmente el Controlador proveé un método muy conveniente de establecer secuencias, este método funciona de una forma similar a un programa de alto nivel orientado al usuario en una computadora personal, utiliza instrucciones de tipo nemónico en idioma ingles para estructurar dichas secuencias. Las instrucciones pueden establecerse desde la estación del operador y se escriben por el usuario en un lenguaje denominado SOPL (Sequence Oriented Procedual Language). Un programa escrito en este lenguaje es una descripcion de la secuencia de operación que puede interpretarse fácilmente paso a paso, ya que el lenguaje se adapta a la experiencia de la mayoría de los ingenieros de proceso. El programa se escribe a partir del diagrama de flujo, el cual representa a su vez el proceso a controlar.

Características importantes del Lenguaje SOPL del Sistema Multifuncional.

Definición de la Unidad de Proceso por el usuario.
Capacidad de manejo de Unidades Multiples.
Capacidad de manejo de Subrutinas.
Capacidad de Cálculo.
Capacidad de manejo de Mensajes.
Capacidad de manejo de Condiciones Anormales (Seguridad).
Amplia variedad de Algoritmos de Control Configurables.

La comunicación entre el Sistema Distribuido conectado al proceso (Controladores Multifuncionales) y el cuarto de control (Estacion del Operador), se realiza por medio del transportador (bus) de datos, proporcionando un enlace de comunicaciones bidireccionales a travéz de las cuales pueden manipularse o desplegarse cualesquiera de los puntos de control, el tráfico del transportador de datos (bus), se controla con un protocolo de comunicaciones que incluye pruebas de direccionamiento a nivel dispositivo y codigos de seguridad BCH. Siendo este sistema de comunicaciones redundante (cable coaxial), esto es si por alguna razón se perdiera un transportador de datos (bus), automáticamente entraria en operación el redundante y se tendría una señal de falla de (bus), pero el proceso no se vería afectado en absoluto.

Otra característica importante que apoya esta selección es que se puede implementar, el control automático ininterrumpido con un solo Controlador Multifunción que, en caso de falla de cualquiera de hasta 8 Controladores, el de soporte tomaría el lugar del que hubiera fallado, y se generaría un mensaje de alerta, pero el proceso no se enteraría de la falla. Otros equipos dan el mismo soporte pero en una relación de uno a uno lo cual eleva el precio de la instalación drasticamente. Y en el presente analisis no se justificaba esta duplicidad de control. En procesos de mucho mayor riesgo, como por ejemplo una planta nuclear, el concepto podria ser otro y aunque fuera más caro se solicitaría el control con respaldo 1 a 1.

La Estación del Operador Mejorada es un paquete completo, que incluye una pantalla (CRT), un teclado interactivo para el control del proceso y llamado de despliegues y todos los dispositivos electrónicos y de almacenaje requeridos para una funcionalidad completa.

La Estación incorpora como características de norma: Tendencias, Promedios por hora, Alarmas, Acción de arranque/paro, Impresiones y Diagnósticos del Sistema. Cada Estación es capaz de operar independientemente de cualquier otra, y no involucran memorias, minicomputadoras u otros dispositivos externos a la Estación. Desde ella, el usuario puede desarrollar programas para ser usados por los Controladores Multifuncionales, o para generar puntos de calculo (C-Points). La programación del Sistema se hace en la Estación, pero la información se carga en el Controlador Multifunción y el ejecuta el Control del Proceso.

La Estación del Operador es la ventana por medio de la cual el operador se comunica con el proceso, fija puntos de ajuste en los controladores, observa las variables del proceso y en caso de falla, los Controladores Multifunción siguen controlando en sus puntos previamente fijados.

NOTA: DE AQUI EN ADELANTE TENDREMOS QUE UTILIZAR DATOS DE LOS FABRICANTES, QUE SE MENCIONAN EN BOLETINES PARTICULARES Y QUE SE ANEXAN EN EL APENDICE, PARA REFERIRNOS A ELLOS SE AGREGARAN LAS LETRAS "A" (Apendice), - LA LETRA INICIAL DEL PROVEEDOR QUE ELABORO EL BOLETIN "C" (Combustion Tec), "H" (Honeywell), "G" (Gordon), "F" (Foxboro), "N" (Newport) - SEGUIDO DEL NUMERO PARTICULAR DEL BOLETIN - FINALMENTE EL NUMERO DE PAGINA DE DONDE SE EXTRAE EL DATO.

SELECCION DE LA ESTACION DEL OPERADOR.

La pag. A-H-BE-2 muestra un diagrama a cuadros con opciones que puede tener la Estación del Operador. Se puede seleccionar entre una Estación Básica (pag.A-H-BE-5) y una Estación Mejorada (A-H-BE-6 y BE-7). La básica solo maneja lazos PID, sin poder implementar funciones lógicas o secuenciales, la Estación Mejorada nos permite todas las funciones previamente mencionadas.

Por lo tanto el primer paso fue seleccionar un paquete de Estación Mejorada (MA-OS535) que incluye: Electrónica de la Estación Mejorada (C-DSB68), CRT de Color 19" (A-VMD33), Kit de Softwere EOS III R535 DISKETTES (P-DK535), Tee-Coax(2 Pzas) (C-KCA01) Cable y Conectores, Fuente de Poder de C A (51110325-100), Electrónica, Ventilador,Etc (P-EMH11).

El segundo paso fue la seleccion del teclado, se tiene las opciones entre teclas (FULL TRAVEL KYBD), o Membrana (MEMBRANE KYBD), al de membrana si le cae un líquido no lo penetra, ni tampoco lo daña el polvo, pero si falla un caracter se debe cambiar toda la unidad y si se va a realizar todo el trabajo de programación con el,es más incomodo de operar, por estas razones se seleccionó, teclas individuales (FULL TRAVEL) (P-DSG55).

El tercer paso fue la selección de la unidad de disco, se tienen tres opciones (todas en disco flexible): Unidad de disco sencillo, unidad de doble disco, y unidad de disco sencillo-sencillo para dos estaciones de operador. Se seleccionó la segunda opción, unidad de doble disco (MP-DFDDL5), ya que sólo se va a adquirir una Estación de Operador y la opción doble nos da la seguridad de un respaldo, si falla un manejador, se puede usar el segundo del sistema dual. (pag AH-BE6).

El cuarto y último paso fue la selección del gabinete, aquí la opción considerada fue (MP-FMSP05) que tiene en su parte inferior espacio para acomodar todas las tarjetas electrónicas de la Estación Mejorada del Operador (Computadora Supervisoria de los Controladores Multifuncionales (que a su vez son computadoras de control digital directo)), tambien tiene una mesa para acomodar el teclado del operador, al frente tiene el espacio para el CRT de color de 19" y en la parte superior se puede instalar la unidad dual de disco. (pag A-H-BE-9).

Fuera de la Estación, pero indispensables para la operación son los Diskettes Operativos y de Configuración (pag. A-H-BE-6), J-DBK15,25,35,y45.

También se requiere la Interfase para impresora sencilla (C-DSP01) y la impresora (C-DSP40) (pag. A-H-BE-7).

SELECCION DEL CONTROLADOR MULTIFUNCION.

Como ya se mencionó en la sección 6.1, se requieren 26 Lazos de Control, por lo que dos (MC's) con capacidad de hasta 16 c/u, son suficientes, el Controlador Multifuncional acepta 16 Entradas analógicas pero solo dá 8 Salidas, por lo que se requiere agregar un ensamble auxiliar de hasta 8 tarjetas,las cuales se seleccionarán apoyandonos en la pag. (A-H-BC 03 01 - 9), observamos que se requieren 2 tarjetas de salidas analógicas PX-OA21 cada una con 4 puntos de salida, para completar las 8 que le faltaban al (MC). Tambien requerimos una tarjeta de entradas analógicas PXIA32 con 8 puntos de entrada, para poder medir señales analógicas de entrada. Finalmente seleccionaremos 1 tarjeta de entradas digitales PXID11 para 16 puntos de 24 Volts CD y 1 tarjeta de salidas digitales de 8 puntos PXOD31 salida a relevador máximo 125 Volts .4 Amp por punto. Se requieren en total 5 tarjetas auxiliares que se pueden acomodar en un solo ensamble auxiliar, por lo que el paquete seleccionado es el de dos Controladores Multifuncionales cuyo número de configuración es MS-MNR202 (pag. A-H-DM-18) con un ensamble auxiliar de tarjetas entrada/salida (I/O FILE), cada uno.

SELECCION DE LA UNIDAD DE INTERFASE DE PROCESO DE BAJA ENERGIA (LEPIU).

Esta Unidad viene siendo el Subsistema de Entrada para recibir las señales de termopares. Para esta Zona de Fundición se van a utilizar 32 termopares.

En el apendice (A-H-PI-26 y PI-27) tenemos la información de las cajas de campo multiseleccionadoras de termopares (Multiplexer Box) dependiendo de la cantidad de termopares, sera el número de cajas, (cada caja acepta 16 termopares). La pag AH-PI26 muestra los modelos para seguridad intrínseca en normas europeas (FM), americanas (PTB), canadienses (CSA), y alemanas (BASEEFA). En nuestro caso no se requiere esta seguridad ya que las cajas no se ubicarán en lugares explosivos. En la pag A-H-PI-27 se encuentran los modelos sin seguridad intrínseca unicamente en las normas americanas.

Seleccionaremos el modelo P-OIM31 que es la caja completa tipo NEMA con sus 2 tarjetas, lógica y de terminales para termopares (TC) ya que tambien existen para RTD y el modelo es diferente.

Finalmente para la electrónica común, se seleccionará de la pag A-H-PI-28 el ensamble electrónico (P-CFA39) que se puede montar en el tablero del Controlador Multifunción (TDC), ya que la otra opción P-CFA61 involucraba gabinetes separados y esto no se justifica, ya que cabe perfectamente en el modulo del Controlador.

6.2.4 SELECCION DE QUEMADORES.

Refiriendonos al boletin (A-C-03F), (Apendice, Combustion Tec,03F), se selecciona el Quemador de Combustoleo a presión media (5 a 40 psig.), el cual tiene flamas largas y luminosas que pueden ser ajustables, esta diseñado para quemar combustoleos pesados precalentados para obtener una viscosidad de 150 SSU o menos = 32 centistokes o menos.

De acuerdo a nuestros datos, del combustoleo suministrado a nuestra planta esperamos tener a 130°C una viscosidad μcp= 19 centipoises ≈ 20.15 centistokes, con una Gravedad = 0.943.

Por lo que este Quemador cumple con buen rango de mejora nuestras necesidades de viscosidad. Ademas esta construido para trabajar con mínimo mantenimiento y larga vida.

Las capacidades del Quemador estan especificadas a 40 psig., para el aire de atomización y el combustoleo, pero puede trabajar a presiones de operación de 125 psig., las correcciones para aire de atomización deberán hacerse en flujo al cambiar la presion de operación, no en combustoleo por ser líquido y ser considerado no compresible.

Del mencionado boletin (A-C-03F), pag. 4 Tabla 3 se selecciona el modelo, M(G)15, ya que tiene una capacidad de 15 MBTU's/Hr.

El número completo del quemador seleccionado es:

03F No. de Serie Quemador Combustion Tec.
- M(G) Tamaño del Quemador.
E Estilo del Quemador Fig.5 Tabla 6 Pag. 7 . Quemador de Atomización en el extremo y aire en linea de centro.
- 15 Capacidad del Quemador 15 MBTU/HR. Tab 3
B Quemador extremo Venturi.

Modelo : 03F - M(G)E - 15B

Como se puede observar del apendice (A-C-03F-4) Tabla 3 . El Quemador seleccionado M(G)15 maneja un máximo de 108 Gal/Hr = 409 Litros/Hora por lo que nuestro rango especificado de 400 L/Hr coincide perfectamente, y maneja 86 scfm (pies cubicos estandard por minuto) a 40 psig de aire de atomización, como nuestras especificaciones marcan presion de 85 psia. se debe hacer la conversión y este rango corresponde a :

Flujo de Aire de Atomización = $86\sqrt{(55)/(85)}$ = 69.2 pies /min
= 117.6 M^3/min.

Por lo que el rango de flujo de aire que acepta el quemador cumple tambien con los requerimientos de nuestras especificaciones que son de 112 M^3/min.

De aqui se concluye que este Quemador es una buena solución a nuestras necesidades.

6.3 CALCULO DE TRANSDUCTORES PRIMARIOS PARA MEDICION DE FLUJO TIPO DE ORIFICIO Y SELECCION DE TERMOPARES.

Se seleccionarán los transductores Placas de Orificio y Tubo Venturi, y se seleccionarán los termopares para esta zona de fundición.

Placa de Orificio para medición de Combustoleo # 6 en un rango de 0 a 400 L/Hr.

Placa de Orificio para medición de Aire de Atomización del combustoleo en la relacion 280 a 1.

Tubo Venturi para medición de Aire de Combustión en relación de 12000 a 1. (Ambas relaciones a una parte de combustoleo).

Las unidades de presion diferencial se dan en milimetros de columna de Agua = mm H2O.

6.3.1 CALCULO DE PLACA DE ORIFICIO PARA MEDICION DE COMBUSTOLEO # 6 DE 0 A 400 L/HR.

Las principales variables involucradas en este cálculo son tres: La razón máxima de flujo, el diámetro del orificio interior y el rango de presión diferencial.

Si cualesquiera dos de estas variables se conocen, la tercera se puede calcular con las ecuaciones y tablas del capitulo 3 y apendice.

De cálculos de tuberías no discutidos en este trabajo se utiliza para Combustoleo # 6 y 400 Lt/Hr, tuberia de 1/2" cedula 40.

DATOS DE DISEÑO.

Fluido		Combustoleo # 6
Flujo Rango Maximo	(q max)=	400 L/Hr
Temperatura Condicion Base	(Tb)=	15 °C
Flujo Normal	(q n)= .8 (q max)=	320 L/Hr
Gravedad Especifica a Temp base	(Gb)=	0.982 @ 15°C
Gravedad Especifica a Temp de flujo	(Gf)=	0.943 @ 130°C
Temperatura de Flujo	(Tf)=	130°C
Factor de Compresibilidad (Liquidos)	(Fp)=	1
Factor Tabla 3.1.2 (pag 43) para Lt/Hr	Nvg =	4.000571
Factor de Expansion Termica	(Fa)=	1.0038

(Fa obtenido de la Fig 3.1.1.4 (pag 41) para Tf=130°C=266°F y Placa de Orificio de Acero Inoxidable Serie 300).

Diámetro Interior de Tuberia 1/2" Cedula 40 (D)=15.8 mm (Apendice Foxboro pag # 5)

Viscosidad a Temp de flujo (dato Pemex) μcp= 19 cp

De la Ec. 3.1.11 (pag 44) tenemos:

$$q = \frac{N\ C\ Fa\ Y\ d^2\ \sqrt{\Delta P} \cdot f(\rho)}{\sqrt{1-\beta^4}}$$

Donde f(ρ) depende de la razón de flujo que se desea manejar másico o volumétrico, en el caso presente por tamaño de tubería y tipo de flujo a manejar se seleccionó un transmisor de presión diferencial Foxboro con orificio integral IFOA donde se sustituye

Y. f(ρ) por ($\sqrt{Fp}\,\sqrt{Gf}$) / (Gb) de Cálculos Experimentales de Laboratorios Foxboro. La Ec. 3.1.11 queda para este caso:

$$q = \frac{(Nvg)\ C\ Fa\ d^2 \sqrt{Fp}\ \sqrt{Gf}\ \sqrt{\Delta P}}{\sqrt{(1-\beta^4)}\ (Gb)} \quad \text{(Litros/Hora)} \quad \text{Ec. 6.3.1.1}$$

Flujo Volumétrico de Líquido a Condiciones Base (Gravedad Específica)

Despejando $\sqrt{\Delta P}$:

$$\sqrt{\Delta P} = \frac{q\ \ (\sqrt{1-\beta^4})\ (Gb)}{Nvg\ (C)\ (Fa)\ d^2 \sqrt{Fp}\ \sqrt{Gb}} \quad \text{Ec. 6.3.1.2}$$

El orificio interior seleccionado es uno estandard de 0.25 pulgadas = 6.35 mm.

$$\beta = d/D = (.25)\ (25.4\ mm)\ /\ (15.8\ mm) = .4018987$$

$$\beta^4 = .0260895 \therefore \sqrt{1-\beta^4} = .986869$$

Para evaluar $\sqrt{\Delta P}$, podemos observar en la Ec. 6.3.1.2 que el único parametro que nos falta evaluar es C (*Coeficiente de descarga*), para lo cual aplicaremos la Ec.(f) Tabla 3.1.4(pag 46) que nos da R_D , y con este numero de Reynolds vamos al apendice (pag AF #8) que relaciona C con R_D .

$$R_D = \frac{(1413.515)\ (Gb)\ (q)}{(\mu cp)\ \ (D)\ (Nvg)} \quad \text{Ec. 6.3.1.3}$$

$$R_D = \frac{(1413.515)\ (.982)\ (400)}{(19)\ \ (15.8)\ (4.000571)} = 462.32$$

Del apendice (pag AF # 8) interpolando β y R_D obtenemos C.

$$C \simeq 0.69$$

$$\sqrt{\Delta P} = \frac{(400)\ \ (.986869)\ \ (.982)}{(4.000571)\ (.69)\ (1.0038)\ (40.3225)\ (1)\ (.9710818)}$$

$$\sqrt{\Delta P} = 3.5728 \qquad \Delta P = 12.764899\ \text{Kpa}$$

$$\Delta P = \frac{12.764899\ \text{Kpa}}{.009791}$$

$$\Delta P = 1303.738\ \text{mm } H_2O$$

Con esto se dá por concluido el cálculo, ya que se ha obtenido el tercer factor que es la presión diferencial, y ya se conocían el rango de flujo, y el diámetro del orificio integral.

6.3.2. CALCULO DE LA PLACA DE ORIFICIO PARA MEDICION DE AIRE DE ATOMIZACION RELACION 280 AIRE : 1 COMB.

Para este cálculo, como en el anterior consideraremos conocidas dos de las tres variables más relevantes, la razón de flujo máximo, y la presión diferencial deseada, así sólo se calcula la relación y el diámetro del orificio de la placa. Notar que en el cálculo anterior se consideró un orificio dado y se calculó la presión diferencial, ahora se considerará dada la presión diferencial y se calculará el diámetro del orificio, quien esta calculando el sistema escoge los parametros que le convienen de acuerdo a su experiencia, y la disponibilidad del mercado.

DATOS DE DISEÑO

Fluido	Aire de Atomización
Flujo Rango Máximo = 280 x 400Lt/Hr=	112000 Lt/Hr= 112 M^3/Hr
Factor de Compresibilidad del gas	(Zf_1)= 1.000
Temperatura de Flujo Absoluta	(Tk_1)= 40°C = 313.15°K
	$\sqrt{Tk_1}$ = 17.696044
Gravedad Específica del gas (Aire)	(G) = 1.0
Presión Base Absoluta (ver pag 42)	(Pb)= 101.325 KPa
Factor N para Presión y Temperatura	(Nvpt)b= 0.06774938
Base Seleccionada Tabla 3.1.2 (pag 43).	
Factor de corrección por expansión	(Fa)= 1.0007
termica Fig 3.1.1.4 (pag 41) Tf=40°C=104°F Placa acero inox.	
Factor de Compresibilidad del gas	(Zb)= 1.000
a Temperatura y Presión Base.	
Temperatura Base Absoluta para el gas	(Tkb)= 15°C =288.15°K
Diámetro Int. de la tuberia 1" Ced 40	(D)= 26.64 mm
(pag AF #5 Tabla 2)	$(D)^2$ = 709.6896
Presión Diferencial deseada	(ΔP)= 2500 mm H2O
(ΔP)= 2500 x .009791 (pag AF # 22)	(ΔP)= 24.4775 KPa
	$\sqrt{\Delta P}$ = 4.9474741
Presión Absoluta a condiones de flujo	(Pf_1)= 100 psia
(Suministrada por el compresor) = 100	x 6.895 = 689.5 KPa
(pag AF # 22)	$\sqrt{Pf_1}$= 26.258332
Viscosidad Absoluta a Temp de flujo	μcp= 0.019 cp

De la Tabla 3.1.3 (pag 45) tenemos el factor de tamaño Sm para flujo de gas volumétrico a condiciones base seleccionada (Ec. m).

$$Sm = \frac{\sqrt{Zf_1}\,\sqrt{Tk_1}\,\sqrt{G}\ (Pb)\ (qvb)}{(Nvpt)b\ (Fa)\ (Zb)\ (Tkb)\ D^2\sqrt{\Delta P}\,\sqrt{Pf_1}}$$

$$Sm = \frac{(1)\ (17.696044)\ (1)\ (101.325)\ (112)}{(.06774938)(1.0007)(1)(288.15)(709.6896)(4.9474741)(26.25833)}$$

$$Sm = \frac{200,821.78}{1\ 801,134.90} = .1114973$$

Ahora se requiere verificar el número de Reynolds del flujo volumétrico gas (aire) a condiciones base seleccionada. Tabla 3.1.4 (pag 46).

$$R_D = \left[83.46744 \ \frac{(G)\ (Pb)}{(Zb)(Tkb)} \times \frac{1}{\mu cp\ D\ (Nvpt)b}\right] qvb$$

$$R_D = 83.46744 \ \frac{(1)\ (101.325)\ (1)\ (112)}{(1)\ (288.15)\ (.019)\ (26.64)\ (.06774938)}$$

(De la Tabla 3.1.6 pag 48) Para placas de orificio tomas de brida y $R_D > 10,000$:

$$\beta_o = \left[1 + \left(\frac{.6}{Sm} + .06\right)^2\right]^{-1/4} \quad \text{(Ec. i)}$$

$$\beta_o = \left[1 + \left(\frac{.6}{.1114973} + .06\right)^2\right]^{-1/4} = \frac{1}{\sqrt[4]{30.6}}$$

$$\beta_o = \frac{1}{2.3521103}$$

$$\beta_o = .4251501$$

$$d = (\beta_o)\ (D)$$

$$d = 11.325998 \text{ mm}$$

$$d = 11.326 \text{ mm}$$

Con esto se puede dar por concluido el cálculo y la Placa de Orificio, se mandará construir con el diámetro interior (d) y diámetro exterior (D).

En el ejercicio anterior se consideró trabajar a presión y temperatura base seleccionada, ahora bien como estos valores seleccionados corresponden con los estandares internacionales SI, (Pb= 101.325 KPa y Tb= 15 °C= 288.15 °K), podemos aplicar la formula para base internacional (Tabla 3.1.3 Formula 1 pag 45):

$$Sm = \frac{\sqrt{Zf_1}\ \sqrt{Tk_1}\ \sqrt{G}\ \ (qv)}{(Nvpt)\ (Fa)\ (Zb)\ (D)^2\ \sqrt{\Delta P}\ \sqrt{Pf_1}}$$

$$Sm = \frac{(1)\ \ (17.696044)\ \ (1)\ \ (112)}{(.1926670)\ (1.0007)\ (1)\ (709.6896)\ (4.9474741)\ (26.25833)}$$

$$Sm = .1114972$$

Ahora se requiere verificar el número de Reynolds del flujo volumétrico gas (aire) a condiciones base estandard.

$$R_D = \left[83.46744 \quad \frac{(G)\ (qv)}{(Zb)(\mu cp)\ \ (D)\ \ (Nvpt)}\right]$$

$$R_D = 83.46744 \quad \frac{(1)\ (112)}{(1)\ (.019)\ (26.64)\ (.192667)}$$

$$R_D = 95{,}860.585$$

Observamos que Sm y R_D corresponden perfectamente con el cálculo anterior y por lo tanto " β o" y "d" están perfectamente calculados para esta Placa de Orificio de Aire de Atomización de Combustoleo.

6.3.3 CALCULO DEL TUBO VENTURI PARA MEDICION DE AIRE DE COMBUSTION EN RELACION DE 12,000 a 1 o 12 M^3 de AIRE a 1 L. de COMBUSTOLEO.

Para este cálculo, consideraremos conocido el rango de flujo máximo, y la presión diferencial deseada, asi sólo se calculará la relación "βo" y el diámetro de la garganta "d" del Tubo Venturi.

DATOS DE DISEÑO

Fluido		Aire de Combustión
Flujo Rango máximo (qvb max)=Relacion x Flujo de Combustoleo		
(qvb max)= 12,000 x 400 L./Hr= 4 800,000 L./Hr = 4 800 M^3/Hr		
Factor de Compresibilidad del gas	(Zf)=	1.000
Temperatura de Flujo Absoluta	(Tk)=	50°C = 323.15°K
Gravedad Específica del gas (Aire)	(G)=	1.000
Presión Base Absoluta	(Pb)=	101.325 KPa
Temperatura Base Absoluta	(Tb)=	15°C = 288.15°K
Factor N para Presión y Temperatura Base Standard (Tabla 3.1.2 pag 43)	(Nvpt)=	0.1926670
Factor de Corrección por Expansión Térmica (Fig 3.1.1.4 pag 41 a Tf=50°C=122°F lamina de acero)	(Fa)=	1.0008
Factor de Compresibilidad del gas a Temperatura y presión base.	(Zb)=	1.000
Diámetro interior de la tuberia 16"	(D)=	406.4 mm
	$(D)^2$ =	165,160.96 mm^2
Presión Diferencial deseada 5" H2O	(ΔP)=	127 mm H2O
(pag AF # 22) 127 x .009791	(ΔP)=	1.243457 KPa
	$\sqrt{\Delta P}$ =	1.115104
Presión Barométrica Local	(Pbl)=	702 mm Hg
Presión Estática del Ventilador	(Pev)=	8" H2O
Presion Absoluta a condiciones	(Pf1)=	(702 x.1333)+(8 x.2487)
(Pf1)= 93.5766 + 1.9896	(Pf1)=	95.5662 KPa
	$\sqrt{Pf1}$ =	9.7757966
Viscosidad Absoluta de operación	μcp=	0.019 cp

De la Tabla 3.1.3 (pag 45) tenemos el factor de tamaño Sm para flujo de gas volumétrico a condiciones base estandard (Ec.1)

$$Sm = \frac{\sqrt{Zf1}\ \sqrt{Tk1}\ \sqrt{G}\quad qv}{(Nvpt)(Fa)(Zb)(D)^2\ \sqrt{\Delta P}\ \sqrt{Pf1}}$$

$$Sm = \frac{(1) \quad x \quad (17.976373) \quad x \quad (1) \quad x \quad (4800)}{(.192667)(1.0008)(1)(165,160.96)(1.115104)(9.7757966)}$$

$$Sm = \frac{86,286.59}{347,159.86}$$

$$Sm = .24855$$

Ahora verificaremos el número de Reynolds de flujo volumétrico de gas (Aire) a condiciones base estandard Tabla 3.1.4 (pag46) (Ec. 1).

$$R_D = \left[83.46744 \quad \frac{(G) \quad x \quad (qv)}{(Zb) \; (\mu cp) \; (D) \; (Nvpt)}\right]$$

$$R_D = \left[83.46744 \quad \frac{(1) \quad x \quad (4800)}{(1)(.019)(406.4)(.192667)}\right]$$

$$R_D = 269{,}304.54$$

Ya que R_D es suficientemente grande (ver pag 47) la fórmula (a) (pag 48), para un Tubo Venturi de Entrada Maquinada es apropiada.

$$\beta o = \left[1 + \left(\frac{0.995}{Sm}\right)^2\right]^{-1/4} = \left[1 + \left(\frac{0.995}{.24855}\right)^2\right]^{-1/4}$$

$$\beta o = 0.4922926$$

El diámetro de la garganta es : $d = (\beta o)(D)$

$$d = 0.4922926 \times 406.4 \text{ mm}$$

$$d = 200.0677 \text{ mm}$$

Como una ayuda para quien requiere calcular, o verificar un cálculo de esta naturaleza de una manera rapida, Foxboro proporciona un nomograma similar, a aquellas reglas de calculo usadas para operaciones aritmeticas antiguamente. Esta regla sirve para cálculos de Placas de Orificio, Tubo Venturi, Tobera de Flujo y Tubo Pitot, y también para cálculo de Cv de Válvulas.

Como ejemplo se rectificará el cálculo del Tubo Venturi para Flujo de Aire de Combustión.

PASOS A SEGUIR :

1o. Se coloca en la Escala Q el Flujo 4800 M^3/Hr (movimiento de cursor).
2o. Se hace coincidir con este punto la Presion Diferencial 127 mm H2O Escala D (movimiento de regleta).
3o. (Mov. de cursor) a Gravedad Especifica (1.0 Aire).
4o. (Mov. de regleta) a Presión Absoluta a condiciones de flujo (aprox. 1 Kg/cm^2 abs.).
5o. (Mov. de cursor) a Temperatura de flujo Escala T (50°C).
6o. (Mov. de regleta) a un Punto Fijo conocido como (d/D Reference).
7o. (Mov. de cursor) a Diametro Interior de la tuberia Escala A (406.4 mm).
8o. Bajo el cursor en la Escala de Tobera de Flujo o Venturi se encuentra la relacion β_o, aproximadamente = .51

Lo cual valida nuestro calculo mas preciso de βo= .4923 .
En el Apendice se muestra una copia de esta regla de cálculo

6.3.4 SELECCION DE TERMOPARES.

Para seleccionar los termopares nos apoyaremos en el Boletin Gordon Temperature Measurement incluido en el Apendice. (AG). Nuevamente este es un ejemplo de selección, existen otras compañías incluso en nuestro Pais sin embargo considero que las fábricas locales de termopares deben mejorar sus normas de calidad, ya que las que he visitado no cuentan con patrones primarios de calibración, por lo que no pueden asegurar el porcentaje de desviación de su producto.

De las especificaciones básicas de diseño tenemos:

Medición de Temperatura en el Techo del Horno.
Rango 1200 a 1450 °C. Longitud de inmersion 14 pulgadas.
Longitud seleccionada total 18 pulgadas.
Del apendice (pag AG #2 y #3) el rango recomendado cae dentro de los límites de operación recomendados para el termopar tipo R (0 a 1450°C).
El elemento seleccionado (pag AG #6) sería:
Un calibre 24 con aislamiento de alumina,ya que esta soporta las temperaturas elevadas mejor que la ceramica, cuyo límite es 1316 °C (ver pag AG # 9).
La longitud se puede seleccionar de 12" a 48" con incrementos de 6".
Para ordenar el elemento del termopar con aislador de alumina:

```
2114 - R - 18 ←— Longitud del elemento.
 ↑      ↑——————— Calibracion.
 └──────────────── Elemento calibre 24 con aisladores de alumina
```

Pero si deseamos ordenar el ensamble completo de termopar con cabeza tipo TH y Tubo Protector de alumina (pags AG #8 y #9):

```
2144 - R - 18 ←— Longitud del Tubo Protector.
 ↑      ↑——————— Calibración.
 └──────────────── Ensamble de elemento calibre 24, con aisla-
                   dores y tubo protector primario de alumina.
```

Medición de Temperatura en Piso del Horno.
Rango 1000 a 1400 °C. Longitud de Inmersion 19 pulgadas.
Longitud seleccionada 24 pulgadas.
Se selecciona un ensamble completo de termopar con cabeza tipo TH y Tubo Protector de Alumina (pags AG #8 y #9):
2144 - R - 24

Medición de Temperaturas Laterales de Horno.
Rango 800 a 1300 °C. Longitud de Inmersion 25 pulgadas.
Longitud seleccionada 30 pulgadas.
Se selecciona un ensamble completo de termopar con cabeza tipo TH y Tubo Protector de Alumina (pags AG #8 y #9):
2144 - R - 30

6.4 SELECCION DE TRANSMISORES DE FLUJO Y TEMPERATURA.

Estos dispositivos son realmente acondicionadores de la señal primaria de los transductores de campo a los equipos de control, los transmisores de flujo y temperatura que se seleccionan, pueden conectarse a controladores analógicos, o controles digitales como es el caso del presente Control Jerárquico.

Nuevamente existen varias opciones disponibles, en el caso de transmisores de flujo de presión diferencial, se seleccionó el equipo Foxboro, por que fué el que pudo satisfacer los requerimientos del proceso plenamente y al mejor precio del mercado, para los transmisores individuales de temperatura, se considero Newport, por las mismas razones anteriores, ambos son equipos de muy alta calidad y confiabilidad.

6.4.1 SELECCION DE TRANSMISOR DE FLUJO PARA MEDICION DE COMBUSTOLEO.

DATOS DE DISEÑO:

Fluido	Combustóleo #6.
Presión de Flujo en el lado de alta	(Pf1) = 10 Kg/cm^2a. (142 psia)
Presión Diferencial máxima	(ΔP) = 1303.738 mm H2O
Temperatura de Flujo	(Tf) = 130 °C
Temperatura Ambiente	(Ta) = 0 a 45 °C
Voltaje de Alimentación	(Va) = 24 Volts C.D.

Refiriendonos al Apendice, (Boletin Foxboro PSS2A 1A3A), Que trata de especificaciones del producto, localizamos el Transmisor o Celda de Presión Diferencial 823 d/p.

Este transmisor acepta una temperatura de proceso o de flujo de -40 a +120°C, nuestro rango de +130°C máxima temperatura de operación queda prácticamente en el limite alto, y el proveedor garantizó una buena operación, por las tolerancias que tiene su producto, la temperatura ambiente que acepta este transmisor es de -40 a +80 °C, y humedad relativa de 0-100%, voltaje de alimentacion +30 Volts c.d.

Entrega una señal de 4 a 20 miliamp c.d. a una carga de salida de 650 Ohms, o de 10 a 50 miliamp a una carga de 600 Ohms.

En cuanto al rango de presión diferencial y presión estática máxima tenemos opciones. En nuestro caso refiriendonos a la pag. (A-F-PSS2A 1A3A-6) Seleccionamos.

823 DP= Transmisor
-I 4 a 20 mA cd de señal de salida
3S Presión estática 21 MPa ,cubierta acero inox 316
1 Fluido para llenar el sensor aceite de silicio.
S Partes del sensor en contacto con fluido AI-316
M Rango (ΔP) entre 6 y 36 KPa,o 25 y 150 pulg H2O
1 Conexiones de proceso 1/4 NPT
-B Indicador con escala cuadratica de 0 a 100 %
CS-E/FD-A- Clasif. certificado no incendiable

El número de modelo completo para los transmisores de flujo de Combustoleo en el rango de 0 a 400 L./Hr es:

823DP-I3S1SM1-B CS-E/FD-A · Foxboro.

6.4.2 SELECCION DE TRANSMISOR DE FLUJO PARA MEDICION DE AIRE DE ATOMIZACION.

DATOS DE DISEÑO:

Fluido	Aire de Atomización.
Presión de Flujo lado de alta	(Pf1)= 7 Kg/cm^2a.(100 psi
Presión Diferencial Maxima	(ΔP)= 2500 mm H2O
	(ΔP)= 24.4775 KPa
Temperatura de Flujo	(Tf)= 40 °C
Temperatura Ambiente	(Ta)= 50 °C
Voltaje de Alimentación	(Va)= 24 Volts c d

Refiriendonos al apendice (Boletin Foxboro PSS2A-1A15A) (Especificaciones de Producto) encontramos el Transmisor o Celda de Presión Diferencial 843 d/p.

Este Transmisor acepta una Temperatura de Proceso o de Flujo de -45°C a +120°C, una Temperatura Ambiente de -50°C a +80 °C, Humedad Relativa de 0 a 100%, voltaje de alimentacion de +12.5 a +36 Volts de c d y su carga de salida puede ir de 0 a 1175 Ohms.Tambien acepta un sobrerrango de presión diferencial y Presión Estatica Máxima de hasta 14 MPa . Y el modelo H tiene como limites de rango de Presión Diferencial 19 y 75 KPa, por lo que nuestra ΔP de 24.4775 KPa requerida, cae perfectamente en este rango. Por lo tanto, el Transmisor requerido para esta aplicación cumple perfectamente las especificaciones de funcionamiento del 843.

El modelo completo del Transmisor seleccionado se obtiene de la pag. (AF-PSS2A 1A15A-3), siendo este:

843 - Celda Transmisora de Presion Diferencial

DP - Configuracion estandard
(El area donde se aplicara no requiere a prueba de explosión).

H - Rango de operacion ΔP entre 19 y 75 KPa
(24.4775 KPa requeridos).

1 - Conectores de proceso 1/4 NPT

M - Seleccion opcional Set de Montaje

CS-E/FN-A (Clasificacion Electrica certificada FM Clase 1, Division 2)

El número de Modelo completo para los transmisores de Aire de Atomización en el rango de 0 a 112 M^3/Hr es:

843-DP-H-1-M-CS-E/FN-A Foxboro.

6.4.3 SELECCION DE TRANSMISOR DE FLUJO PARA MEDICION DE AIRE DE COMBUSTION.

DATOS DE DISEÑO:

Fluido	Aire de Combustión.
Presión de Flujo lado de alta	(Pf1) = 95.6 KPa
Presión Diferencial máxima	(ΔP) = 127 mm H2O
	(ΔP) = 5 pulg H2O
Temperatura de Flujo	(Tf) = 50 °C
Temperatura Ambiente	(Ta) = 45 °C
Voltaje de Alimentación	(Va) = 24 Volts cd

Para la selección de este equipo nuevamente nos referimos al Boletin (A-F-PSS2A 1A3A), y encontramos el transmisor o Celda de Presión Diferencial Foxboro 823 d/p.

Este transmisor acepta una Temperatura de Proceso o de Flujo de -40 a +120°C, nuestro rango de 50°C cae practicamente al centro de estos limites, la Temperatura Ambiente que acepta este transmisor es de -40 a +80°C, de nuevo cumple perfectamente los requisitos de nuestro proceso, en cuanto a voltaje de suministro acepta hasta 30 V cd, y su humedad relativa esta en el rango de 0 a 100 %, entrega una señal de 4 a 20 mA. a una carga de 650 Ohms.

En cuanto al rango de Presión Diferencial y Presión Estatica máxima, tenemos opciones. En este caso refiriendonos a la pag (A-F-PSS2A 1A3A-6) Seleccionamos:

823DP = Transmisor
- -I Señal de Salida 4 a 20 mA cd
  - -1P Presion Estática hasta 4 MPa
    - 1 Fluido para llenar el sensor aceite de silicio
      - N Partes del sensor en contacto con el fluido Aleación Cobalto-Nickel-Cromo (estandard)
        - L Rango de Presión Diferencial entre (1.2 y 7.2 KPa) ó (5 y 30 pulg de H2O)
          - 1 Conectores de Proceso 1/4 NPT
            - -B Indicador con escala cuadrática de 0-100%
              - CS-E/FD-A Clasificación Eléctrica Certificado no Incendiable.

El número de modelo completo para los transmisores de flujo de Aire de Combustión en el rango de 0 a 4800 M^3/Hr es:

823DP-I1P1NL1-B CS-E/FD-A Foxboro.

6.4.4 SELECION DE TRANSMISORES DE TEMPERATURA.

Para los lazos de control de temperatura, se requiere que la señal del termopar se acondicione de la señal proporcionada por estos en milivolts a una señal análoga de 4 a 20 miliamperes proporcional a la entrada de milivoltaje.

El Controlador Multifuncional (C.D.D.) seleccionado, acepta estas entradas (de 4 a 20 mA) en cualquier curva de termopar, y en cualquier rango, y proporciona al acondicionador de señal ó transmisor, voltaje de alimentacion de 24 Volts cd en el sistema de alimentación y medición de 2 hilos,esto significa que las líneas de alimentación de potencia se utilizan tambien como líneas de señal, lo cual simplifica el alambrado de campo,eliminando la necesidad de líneas separadas de potencia y alimentacion.

Refiriendonos al Apendice, Boletin Newport 1989/90 Data Book encontramos en la sección 14, el transmisor aislado para termopares, en dos hilos, de 4 a 20 miliamperes, Modelo 502-A.

Este excelente transmisor tiene la facilidad de configurar y calibrar supresión de cero y rango de operación, con el ajuste de potenciómetros de presición de 15 vueltas y seleccionando puentes adecuados (selectores), por lo que prácticamente se puede configurar cualquier rango de operación.

Se considerará como ejemplo de selección del transmisor, el que se conectará al termopar del lazo de control de temperatura del combustóleo (cuyo punto de referencia de control es 130 °C), y al cual se le seleccionará un rango de operacion de 0 a 200 °C.

Con referencia a la pagina (A-N-1989/90 DATA BOOK 14 - PAG 8 A 10), seleccionamos el transmisor:

502A - Transmisor de Termopar de 4 a 20 mA.

- J Tipo de Termopar rango nominal 0 a 500 °C.

- * Indicador de Termopar abierto sobrerrango (25mA)

- MDT1 Montaje en riel tipo DIN.

OPCIONES: - FS Escala 0°C-4 mA 200°C-20 mA.

- CBP1 Aislamiento en cubierta.

El modelo completo del transmisor seria:

502A-J-*-MDT1-FS-CBP1 Newport.

6.5 SELECCION DE VALVULAS DE CONTROL.

1) Flujo de Combustoleo # 6 Rango de 0 a 400 L /Hr.
2) Flujo de Aire de Atomización Rango de 0 a 112 M^3/Hr.
3) Flujo de Aire de Combustión Rango de 0 a 4800 M^3/Hr.

Existen varias opciones disponibles en estos dispositivos finales de control, entre las que destacan Foxboro, Honeywell, Fisher Governor, Jamesbury, etc, nuevamente para la selección de una marca en particular se imponen los criterios mencionados en la seccion 6.2 en el caso actual se selecciona la marca Foxboro, por que satisface plenamente las necesidades,y la experiencia que ellos tienen en equipos neumáticos ya es una garantia, cabe mencionar que Foxboro ha contado con investigadores que han hecho contribuciones muy valiosas a la tecnología de medición y control neumático. El costo de estas valvulas fue compatible con otras marcas y presento una mayor seguridad en cuanto a servicio y experiencia local.

6.5.1 SELECCION DE VALVULA DE CONTROL DE FLUJO DE COMBUSTOLEO # 6. RANGO 0 - 400 L /HR.

Como primer paso se debe calcular el Cv de la valvula:

DATOS DE DISEÑO

Fluido	Combustóleo # 6.
Presión de Flujo a la entrada de la valvula	(Pf1)=135 psia
Presión de Flujo a la salida de la valvula	(Pf2)=125 psia
Diferencial de Presión en la valvula	(ΔP)= 10 psi
Flujo máximo requerido	(qv)= 400 L /Hr = 1.72 Gal/min
Temperatura de operación	(Tf)= 90 °C
Gravedad Específica del Combustoleo	(G)= 0.943
Tamaño de la valvula requerido para líquidos = (Cvl)	

$$Cvl = qv \sqrt{\frac{G}{\Delta P}} = 1.72 \times \sqrt{\frac{.943}{10}} = 0.5282$$

Asi que el tamaño requerido de la valvula o Cv es igual a 0.5282, esto quiere decir que si encontraramos una válvula exactamente con este Cv, y se cumplieran todas las condiciones de presión, gravedad, etc con una caida de presión de 10 psi en la válvula y 100% de abertura circularían a travez de ella los 400 L /Hr deseados, obviamente se debe dar alguna tolerancia y se escoge un Cv mayor al calculado.

En el apendice Boletin Foxboro GS-4-1A1 encontramos el modelo de la Válvula de Control Stabilflo Serie V1, Tipo Globo.

Para esta aplicación se selecciona un modelo lineal, y en la tabla 1 vemos información de válvulas desde 1/2 " hasta 1 " pasando por 3/4 ". La diferencia de precio entre las tres no es muy grande, sin embargo la válvula de 1/2 " es la más económica y tiene la ventaja de que se le puede cambiar el tamaño del asiento (trim) y con esto tenemos variedad de Cv´s desde 1 hasta 5.

De esta manera si fuera necesario incrementar la razón de flujo a travéz de la válvula, con solo cambiar el asiento que es un aditamento económico y de fácil reemplazo se modificaría el Cv de la válvula. Por esta razón se selecciona la valvula de 1/2 " con asiento de 1/4 " para dar un Cv = 1 , que es el mínimo disponible, pero que cumple perfectamente con el .5282 calculado.

La presión de suministro de aire seleccionada es 20 psi.

El Actuador seleccionado es el P250 ya que en este rango manejamos presión al cierre de 0 a 675 y 0 a 900 psi, asi que los 135 psia de operación no afectan al control. Se agrega información en el Apendice (Boletin Foxboro TI 31-7a sobre selección de Actuadores).

La acción de la válvula se selecciona de Aire para abrir, asi a falla de aire de suministro, la válvula cierra que es la operación segura.

Carrera 3/4 ". (Unica carrera disponible en este tamaño).

Límites de temperatura de operación 0 a 208 °C.

Cuerpo : Acero al Carbon.

Asiento (Trim) 1/4 " Acero Inox. 316.

Esta válvula se complementa con el posicionador Corriente a Neumático E69P (Apendice Boletin Foxboro PSS4-10A2A). El cual convierte la entrada de corriente directa nominal de 4 a 20 mA a una señal neumática de 0.2 a 1 Kg/cm^2 , con retroalimentación de posición de válvula.

El número completo de este posicionador (se obtiene del apendice (A) Boletin Foxboro (F)-PSS4-10A2A pag 2).

E69P - T Aplicación en area no explosiva.

- I Rango de señal de entrada 4 a 20 mA.

- 1 Señal de salida 20 psi ó 140 KPa.

- S Válvula serie V1 Actuador P-25.

Posicionador : E69P-T-I-1-S Foxboro.

6.5.2 SELECCION DE VALVULA DE CONTROL DE FLUJO DE AIRE DE ATOMIZACION RANGO DE 0 - 112 M^3/HR.

Como primer paso calcularemos el Cv de la Valvula:

DATOS DE DISEÑO

Fluido Aire de Atomización

Presión de Flujo a la entrada de la válvula (Pf1)= 90 psia

Presión de Flujo a la salida de la válvula (Pf2)= 88 psia

Diferencial de Presión en la válvula (ΔP)= 2 psig

Flujo máximo requerido = (qv) = 112 M^3/Hr = 493.14 Gal/min

Gravedad Específica del Aire (G)= 1.0

Temperatura Absoluta del flujo (Tf)= 50 °C= 582 °R

Tamaño de la valvula requerido para gases = (Cvg)

$$Cvg = \frac{qv}{1360}\sqrt{\frac{(Tf)(G)}{(\Delta P)(Pf2)}} = \frac{493.14}{1360}\sqrt{\frac{(582)(1)}{(2)(87)}} = 0.6631$$

Así que el tamaño de la válvula requerido ó Cvg= 0.6631 .

Para esta aplicación como en elcaso anterior se selecciona un modelo lineal, por que si recordamos de la Teoría de Válvulas de Control, la válvula lineal presenta un flujo proporcional a su salida y como el Cv requerido es muy pequeño, el mínimo disponible es 1 esta válvula trabajará alrededor del 66% de abertura a flujo máximo, lo cual es un rango adecuado de operación, en cambio en igual porcentaje la válvula con el mismo Cv, trabajaría mucho mas cerrada ocasionando desgaste innecesario del asiento y un control deficiente.

En el apendice (Boletin Foxboro GS-4-1A1) encontramos el modelo de Valvula de Control Stabilflo Serie V1. Cuerpo de Globo.

En la Tabla 1 observamos las opciones que van de válvulas de 1/2" a 1", seleccionamos la Válvula Lineal de 1/2" con asiento (Trim de 1/4") para un Cv=1 que cumple perfectamente con el .6631 calculado.

La Presión de alimentación seleccionada es 20 psi que es el valor nominal en la fábrica, y el Actuador es de nuevo el P250, ya que en este rango manejamos presión al cierre de 0 a 675 y de 0 a 900 psi, asi que las 90 psia de operacion del Aire de Atomización no afectan al control. (Apendice Boletin Foxboro T131-7a Actuadores).

La acción de la Valvula se selecciona Aire para Cerrar, así que en caso de una falla del suministro de Aire, la válvula se abre completamente, que es la operación segura, en el caso anterior (Válvula de Combustoleo, en caso de falla de suministro, la válvula cierra, porque utiliza aire para abrir).

Carrera 3/4 pulgada.

Límites de Temperatura de Operacion 0 a 208 °C.

Cuerpo : Acero al Carbon.

Asiento (Trim) 1/4" Acero Inoxidable 316.

Esta válvula se complementa con el posicionador Corriente a Neumático E69P (Apendice Boletín Foxboro PSS4-10A2A). El cual convierte la entrada de corriente directa estandard 4 a 20 mA a una señal neumática con retroalimentación de posición de la válvula.

El número completo se obtiene de (A-F-PSS4-10A2A Pag 2)

E69P - T Aplicación en área no explosiva.

- I Rango de Señal de entrada 4 a 20 mA.

- 1 Señal de salida 20 psig o 140 KPa.

- S Valvula serie V1 Actuador P-25.

Por lo que el número completo del posicionador viene a ser:

E69P-T-I-1-S Foxboro.

6.5.3 SELECCION DE VALVULA DE CONTROL DE FLUJO DE AIRE DE COMBUSTION RANGO DE 0 A 4800 M^3 / HR.

Como primer paso calcularemos el Cv de la válvula:

DATOS DE DISEÑO:

Fluido	Aire de Combustión.
Presión de Flujo Entrada de la válvula	(Pf1)= 4" H2O
Presión de Flujo Salida de la válvula	(Pf2)= 3.6" H2O
(Pf2)= (3.6) x (0.03606) + 14.71 psi =	14.83 psia
Diferencial de Presión en la válvula	(ΔP)= .4" H2O
(Δ P)= (0.4) x (0.03606)	= 0.014424 psig
Flujo Máximo requerido	(qv)= 4800 M^3/Hr = 21136 Gal/min
Gravedad Específica del Aire	(G)= 1
Temperatura absoluta de flujo	(Tf)= 60°C= 600°R
Tamaño de la válvula requerida para gases	(Cvg)

$$Cvg = \frac{qv}{1360}\sqrt{\frac{(Tf)\ (G)}{(\Delta P)\ (P2)}} = \frac{21136}{1360}\sqrt{\frac{(600)\ (1)}{(.014424)(14.83)}} = 823$$

Así que el tamaño de la válvula requerido,Cv es igual a 823.

En el Apendice (Boletin Foxboro TI031-016), encontramos el modelo de Válvula de Control de Mariposa Serie V3000, y en la pag 2 se especifica que esta valvula se debe seleccionar para operar en el rango entre 30 y 60 grados de abertura y la válvula que cumple mejor es la de 10 pulgadas de diametro.

La presión de suministro seleccionada para estandarizar será de 20 psig y el Actuador seleccionado es el Foxboro modelo P110 requerido para valvulas de 10, 12, y 16 pulgadas. (A-F-TI031-016 pag 2).

Cuerpo de la válvula Acero al Carbon para operar a altas temperaturas (limite 200°C).

POSICIONADOR referirnos a (A-F- PSS4-10A2A pag 2) :

E69P - T Aplicacion en área no explosiva.

- I Rango de Señal de entrada 4 a 20 mA.

- 1 Señal de Salida 20 ó 35 psi ó 140 ó 240 KPa.

- R Válvula No. V1 o V9000 o V9300 · Actuador P110.

El número completo del posicionador sera:

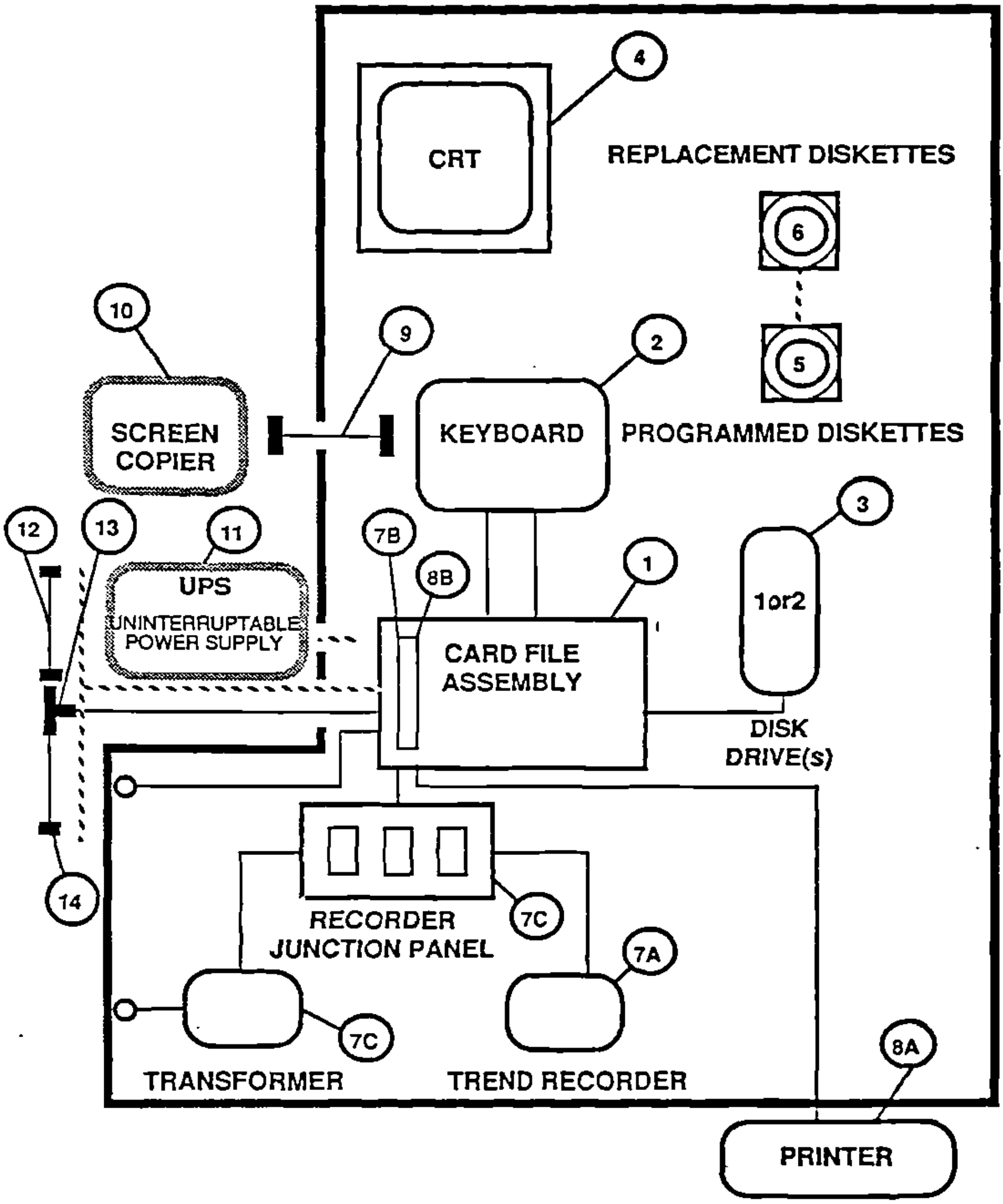
E69P-T-I-1-R Foxboro.

APENDICE. Datos de Fabricantes.

INDICE

BASIC/ENHANCED OPERATOR STATIONS

BASIC AND ENHANCED OPERATOR STATIONS
GENERAL CONFIGURATION GUIDELINES



BASIC/ENHANCED OPERATOR STATIONS

MODEL NUMBER	DESCRIPTION

BASIC OPERATOR STATION

For each Basic Station, perform a minimum of two steps to document two model numbers.

1. SELECT THIS BASIC STATION BASE PACKAGE :

MA-OS616 BASIC OP STA BASE PKG W/FULL TVL KB, W/O FDD

QTY	MODEL #	DESCRIPTION
1	C-DSB56	BASIC OP STA ELECTRONICS FOR US FURN MOUNT
1	A-VMD33	19" COLOR CRT, 50/60HZ FOR US FURN MOUNT
1	P-DSG56 *	FULL TRAVEL KYBD FOR BASIC OP STA-FURN MT
1	P-DK616	R616 5 1/4" FDD PROGRAM MEDIA KIT
1	C-KCA01	COAX TEE (QTY 2)
1	P-EMH11	ELEC. MTG HDWR, FAN REAR DOOR, KB TRAY

2. SELECT ONE FLOPPY DISK STYLE:

MP-DFDSN5	SINGLE FDD (1), ANY SGL BAY MTG FOR 1 OP STA
MP-DFDDL5	DUAL FDD (2), ANY SGL BAY MTG FOR 1 OP STA
MP-DFSSN5	SINGLE/SINGLE FDD (2), ANY SGL BAY MTG FOR 2 OS

BASIC OPERATOR STATION MODULEs

C-DSB56	BASIC OP STA ELECTRONICS FOR US FURN MOUNT
A-VMD33	19" COLOR CRT, 50/60HZ FOR US FURN MOUNT
* P-DSG56	FULL TRAVEL KYBD FOR BASIC OP STA-US FURN MT
P-DK616	R616 5 1/4" FDD PROGRAM MEDIA KIT
P-DD705	R616 5 1/4" FDD DIAGNOSTIC MEDIA KIT
C-KCA01	COAX TEE (QTY 2)
P-EMH11	ELEC. MTG HARDWARE, FAN REAR DOOR, KB TRAY

* NOTE: A plastic cover is available for the Basic Operator Station Keyboard to protect the internals from liquid spillage. This cover is pliable and the keys retain their full travel operation. The cover should be procured by the Customer directly from the manufacturer:

C. Sharkey Keyboard Covers, Inc.
10016 Sandmeyer Lane
Philadelphia, PA 17116
(215) 969-8783

Two versions of the cover are available (listed with manufacturer's part #)

4185 Cover placed under the bezel and key caps
4195 Cover placed over the top of the key caps

BASIC/ENHANCED OPERATOR STATIONS

MODEL NUMBER	DESCRIPTION

ENHANCED OPERATOR STATION (III) PACKAGES

For each EOS, perform a minimum of three steps to document three model numbers.

1. SELECT THIS EOS BASE PACKAGE:

MA-OS535	ENH OP STA BASE PKG, W/O KB, W/O FDD

QTY	MODEL #	DESCRIPTION
1	C-DSB68	ENHANCED OP STA ELECTRONICS
1	A-VMD33	19" COLOR CRT, 50/60;HZ FOR US FURN MOUNT
1	P-DK535	EOS III R535 SOFTWARE KIT, 5 1/4". DISKETTES
1	C-KCA01	COAX TEE (QTY 2)
1	51110325-100	AC POWER CABLE W/CONNECTOR
1	P-EMH11	ELEC. MTG HDWR, FAN REAR DOOR, KB TRAY

2. SELECT ONE KEYBOARD STYLE:

P-DSG55	FULL TRAVEL KYBD FOR ENHANCED OP STA-US FURN
P-DSG54	MEMBRANE KYBD FOR ENHANCED OP STA-US FURN

3. SELECT ONE FLOPPY DISK STYLE:

MP-DFDSN5	SINGLE FDD (1), ANY SGL BAY MTG FOR 1 OP STA
MP-DFDDL5	DUAL FDD (2), ANY SGL BAY MTG FOR 1 OP STA
MP-DFSSN5	SINGLE/SINGLE FDD (2), ANY SGL BAY MTG FOR 2 OS

ENHANCED OPERATOR STATION MODULES

C-DSB68	ENHANCED OP STA ELECTRONICS
A-VMD33	19" COLOR CRT, 50/60HZ FOR US FURN MOUNT
P-DK535	EOS III R535 SOFTWARE KIT, 5 1/4" DISKETTES
J-DD535	R535 OP STATION & HIWAY DIAGNOSTIC DISKETTES
C-KCA01	COAX TEE (QTY 2)
P-EMH11	ELEC. MTG HARDWARE, FAN REAR DOOR, KB TRAY

* ENHANCED OPERATOR STATION DATA BASE DISKETTES - 5 1/4" FDD

J-DBK15	DATA BASE CONFIG. DISKETTES (BOX OF 10)
J-DBK25	TREND DATA BASE DISKETTES (BOX OF 10)
J-DBK35	SOPL DATA BASE DISKETTES (BOX OF 10)
J-DBK45	RECIPE DATA BASE DISKETTES (BOX OF 10)

BASIC/ENHANCED OPERATOR STATIONS

MODEL NUMBER	DESCRIPTION

* ENHANCED OPERATOR STATION DATA REPLACEMENT DISKETTES - 5 1/4" FDD

82116406-001	REPLACEMENT CONFIGURATION PROGRAM DISKETTE
82116404-001	REPLACEMENT OPERATING PGM DISKETTE (NO RECIPE)
82116405-001	REPLACEMENT OPERATING PGM DISKETTE (W/RECIPE)
82116410-001	REPLACEMENT UTILITY DISKETTE (INCLUDES DATA BASE PRINT AND COPY)
82409484-001	REPLACEMENT DHP CONFIGURATION DISKETTE

NOTE: For 8" FDD replacement media for previous releases, refer to your appropriate Regional Center.

BASIC/ENHANCED OPERATOR STATIONS OPTIONS

ONLY ONE EXTERNAL I/F FROM:

C-DSP01	SINGLE PRINTER INTERFACE
J-DSP02	MULTI-PRINTER INTERFACE
* C-DSR01	RECORDER INTERFACE
C-DSP40	PRINTER
C-DSP41	PRINTER WITH PEDESTAL
P-VHC21	VIDEO COPIER 60HZ FOR BASIC/ENHANCED OP STA
P-VHC22	VIDEO COPIER 50HZ FOR BASIC/ENHANCED OP STA
P-VHC25	VIDEO COPIER, COMBINATION, 60HZ
P-VHC26	VIDEO COPIER, COMBINATION, 50HZ
P-KHC12	VIDEO COPIER CABLE (FOR BASIC/ENH STA) 25'

ENHANCED OPERATOR STATION OPTION

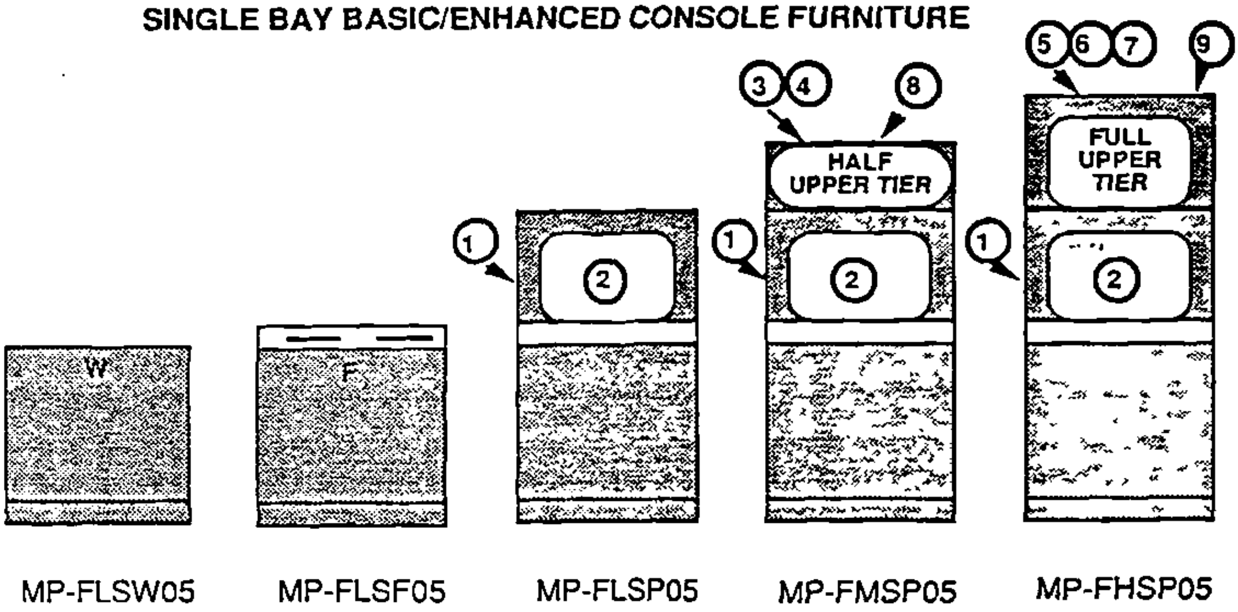
J-DST53	DOT TREND GENERATOR

* NOTE: The Recorder Interface does not include Recorders or furniture mounting. These must be specified separately. Refer to the Basic section (BA-) for a list of the available Honeywell manufactured recorders.

BASIC/ENHANCED OPERATOR STATIONS

CONFIGURATION GUIDE

SINGLE BAY BASIC/ENHANCED CONSOLE FURNITURE



OPTIONS:

1. MP-MMEP05 REAR DOOR AND BLANK TABLE TOP FOR EMPTY CONSOLE
2. P-EPB11 LOWER TIER POD BLANK PANEL
3. P-EFK11 1/2 U.T. BEZEL AND FLOPPY MOUNT BAS/ENH
4. P-EPK11 1/2 U.T. BEZEL AND BLANK PANEL
5. P-EPB15 FULL U.T. BEZEL AND BLANK PANEL
6. P-EPB16 FULL U.T. BEZEL ONLY
7. P-EPB17 FULL U.T. BEZEL AND FLOPPY MOUNT BAS/ENH
8. MP-TRPH09 * 8 PEN (3REC) TR MTG PKG, 1/2 U.T. BAS/ENH
9. MP-TRPH17 * 16 PEN (6 REC) TR MTG PKG, FULL U.T. BAS/ENH
10. MA-CBB01 CIRCUIT BREAKER BOX PACKAGE

* NOTE:
The Trend Recorder mounting package options do not include the Recorders or the Interface Card (C-DSR01). These must be specified seperately. Refer to the Basic section (BA-) for a list of the available Honeywell manufactured recorders.

BASIC/ENHANCED OPERATOR STATIONS

MODEL NUMBER	DESCRIPTION
FURNITURE	
MP-FLSW05	SINGLE BAY TABLE TOP Console Base Assembly (No Power Entry) Plain Table Top
MP-FLSF05	SINGLE BAY TABLE TOP WITH FLOPPY MOUNT Console Base Assembly Floppy Mount Table Top
MP-FLSP05	SINGLE BAY SCREEN LOWER TIER Console Base Assembly Pod Assembly
MP-FMSP05	SINGLE BAY SCREEN WITH HALF UPPER TIER Console Base Assembly Pod Assembly W/Upper Tier Upper 1/2 Height Pod Assembly
MP-FHSP05	SINGLE BAY SCREEN WITH FULL UPPER TIER Console Base Assembly Pod Assembly W/Upper Tier Upper Full Height Pod Assembly
FURNITURE OPTIONS	
MP-MMEP05	REAR DOOR AND BLANK TABLE TOP FOR EMPTY CONSOLE
P-EPB11	LOWER TIER POD BLANK PANEL
P-EFK11	1/2 U.T. BEZEL AND FLOPPY MOUNT BAS/ENH
P-EPK11	1/2 U.T. BEZEL AND BLANK PANEL
P-EPB15	FULL U.T. BEZEL AND BLANK PANEL
P-EPB16	FULL U.T. BEZEL ONLY
P-EPB17	FULL U.T. BEZEL AND FLOPPY MOUNT BAS/ENH
MA-CBB01	CIRCUIT BREAKER BOX PACKAGE
MP-TRPH09*	8 PEN (3 REC) TR MTG PKG, 1/2 U.T. BAS/ENH
MP-TRPH17*	16 PEN (6 REC) TR MTG PKG, FULL U.T. BAS/ENH

* NOTE: The Trend Recorder Mounting Package options do not include the Recorders or the Interface Card (C-DSR01). These must be specified separately. Refer to the Basic section (BA-) for a list of the available Honeywell manufactured Recorders.

MULTIFUNCTION CONTROLLER PDL (NON UAC) HIGH DENSITY TERMINAL PANELS CONFIGURATION TABLE

# OF CTLRS	PDL CONFIGURATION NUMBER	# OF I/O FILES/CTLR 2	1	HARDWARE PACKAGE. IDENTIFIERS
1	MS-MNR101	0	1	1E
	MS-MNR110	1	0	3E
2	MS-MNR202	0	2	2E
	MS-MNR211	1	1	16
	MS-MNR220	2	0	33
3	MS-MNR303	0	3	21
	MS-MNR312	1	2	23
	MS-MNR321	2	1	33-5E
	MS-MNR330	3	0	33-6E
4	MS-MNR404	0	4	12-5E
	MS-MNR413	1	3	23-5E
	MS-MNR422	2	2	33-4E
	MS-MNR431	3	1	33-56
	MS-MNR440	4	0	33-36
5	MS-MNR505	0	5	22-5E
	MS-MNR514	1	4	23-2E
	MS-MNR523	2	3	33-14
	MS-MNR532	3	2	33-14
	MS-MNR541	4	1	33-36-5E
	MS-MNR550	5	0	33-36-3E
6	MS-MNR606	0	6	22-2E
	MS-MNR615	1	5	12-23
	MS-MNR624	2	4	23-23
	MS-MNR633	3	3	33-65-2E
	MS-MNR642	4	2	33-36-2E
	MS-MNR651	5	1	33-36-16
	MS-MNR660	6	0	33-36-36

LOW ENERGY PIU
DETAILED SYSTEM CONFIGURATOR

5. Common Card Files and Control Room Cabinets

Frequently the common card files will be mounted in other cabinets; therefore, 2 mounting forms are offered. The control room cabinet contains a bulk power supply. There is power and space available for three common card files.

The standard cabinets are 24"x24"x70" and 24"x24"x77"; the 'Phoenix 30"' is also available. -All-other arrangements are special (RPQ/RDO). The 30" cabinet includes power entry and cable ladders.

6. Phase Reference Transformer

If the line frequency varies more than+/- 0.1% of 50 or 60 HZ, a phase reference transformer is required in order to meet the common mode and normal mode rejection ratio specifications. Only one phase reference transformer is required per cabinet.

7. Top Entry

This option provides for entry of the I/O cables only through the top of the cabinet.

8. Intrinsic Safety Option

Three types of barrier boxes are offered to meet the requirements of FM, PTB and CSA Certification Agencies. Each box has enough barriers for one common card file with both basic and RTD multiplexers. Wiring details are shown in the PIU Installation Manual, PI-09-01. This box is free standing and is to be mounted by the customer.

9. Accessories

Scaling resistors may be connected across input terminals by the customer to convert current inputs to voltage as required.

10. Maximum Scan Rate Table

To determine the maximum scanning capability use the following table:

Number of analog inputs @ 60 sec scan	=	______
Number of analog inputs @ 15 sec scan x 4	=	______
Number of analog inputs @ 5 sec scan x 12	=	______
Number of mux boards w/inputs that require CJRx2	=	______
A/D offset readings		4

TOTAL MUST NOT EXCEED 960

PROCESS INTERFACE UNITS

LOW ENERGY PIU
INTRINSICALLY SAFE
SYSTEM CONFIGURATION

	MODEL NUMBER	DESIRED QTY OF POINTS	DESCRIPTION	DIVIDE BY*	QTY
IS MUX	P-FIM14		FM TC W/NEMA Box	16	
BOARD	P-FIM24		FM RTD - 100 Ohm W/NEMA Box	16	
SETS	P-OIM14		PTB TC W/NEMA Box	16	
	P-OIM24		PTB RTD - 100 Ohm W/NEMA Box	16	
	P-CIM14		CSA TC W/NEMA Box	16	
	P-CIM24		CSA RTD - 100 Ohm W/NEMA Box	16	
	P-BIM14		BASEEFA TC W/NEMA	16	
	P-BIM24		BASEEFA RTD W/NEMA	16	
SPLIT SHIPMENTS ARE NOT I. S. QUALIFIED BY ANY CERTIFICATION AGENCY.					

MODEL NUMBER	DESCRIPTION
LE INTRINSICALLY SAFE MULTIPLEXOR - MAX 16 UNITS/CCFA	
P-FIM14	TC LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-FIM24	RTD LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-OIM14	TC LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-OIM24	RTD LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-CIM14	TC LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-CIM24	RTD LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-BIM14	TC LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY
P-BIM24	RTD LOGIC & TERM BDS, CABLES & NEMA 4 BOX ASSY

FOR I.S. QUALIFIED APPLICATION, ONE OPTIONAL BARRIER BOX PER CCFA MUST BE SELECTED. SEE CONFIGURATION NOTE 4 (PI-26) AND CCFA OPTIONS (PI-30).

PROCESS INTERFACE UNITS

LOW ENERGY PIU
NON-INTRINSICALLY SAFE
SYSTEM CONFIGURATION

	MODEL NUMBER	DESIRED QTY OF POINTS	DESCRIPTION	DIVIDE BY*	QTY
NON IS	P-OIM31		TC W/NEMA	16	
MUX	P-OIM34		TC W/O NEMA	16	
BOARD	P-OIM41		RTD 100 Ohm W/ NEMA	16	
SETS	P-OIM44		RTD 100 Ohm W/O NEMA	16	
NON IS	P-OIM32		TC Term Brd and Hdw W/NEMA		
MUX	P-OIM33		TC Logic Brd and Cables		
BOARDS	P-OIM42		RTD Term Brd and Hdw W/NEMA		
FOR	P-OIM43		RTD Logic Brd and Cables		
SPLIT					
SPMNTS	P-NMA11		NEMA 4 Box		
* Round up					

MODEL NUMBER	DESCRIPTION
LE NON-INTRINSICALLY SAFE MULTIPLEXOR - MAX 16 UNITS/CCFA	
P-OIM31	TC LOGIC&TERM BDS, CABLES & NEMA ASSY-NON IS
P-OIM34	TC LOGIC&TERM BDS, MTG HDWE & CABLES-NON IS
P-OIM41	RTD LOGIC&TERM BDS, CABLES & NEMA ASSY-NON IS
P-OIM44	RTD LOGIC&TERM BDS, MTG HDWE & CABLES-NON IS

SPLIT SHIPMENTS ARE NOT I.S. QUALIFIED BY ANY CERTIFICATION AGENCY.

P-OIM32	TC TERM BOARD & NEMA 4 BOX ASSY-NON IS
P-OIM33	TC LOGIC BOARD & CABLES-NON IS
P-OIM42	RTD TERM BOARD & NEMA 4 BOX ASSY-NON IS
P-OIM43	RTD LOGIC BOARD & CABLES-NON IS
P-NMA11	NEMA 4 BOX

PROCESS INTERFACE UNITS

LOW ENERGY PIU
DETAILED SYSTEM CONFIGURATION

CARD FILES/CABINETS

	MODEL NUMBER	No. MUX Boxes	DESCRIPTION	DIVIDE BY*	QTY	
COMMON CFA/W FIRMWARE	P-CFA39		CCFA, TDC	16		
	P-CFA61		CCFA, TDC 2000 Mount	16		
		No. of CCFA				
CONTROL ROOM CAB. W/O COMM CFA	P-ELE61		30" Cab 220VAC 50HZ (max 4CCFA)	4		
	P-ELE62		30" Cab 120VAC 60HZ (max 4CCFA)	4		
	P-ELE63		27 x 70 in Cab. 220VAC 50HZ "	4		
	P-ELE51		27 x 70 in Cab. 120VAC 60HZ "	4		
	P-ELE52		27 x 77 in Cab. 220VAC 50HZ "	4		
	P-ELE53		27 x 77 in Cab. 120VAC 60HZ "	4		
			Total CCFA and Cabinets			
			Total Cabinets			
CABINET OPTIONS						
TOP ENTRY	P-OTE11		Top Entry I/O Cables (30" Cab)		1/Cab	
	P-OTE13		Top Entry I/O Cables (27" Cab)		1/Cab	
	P-OCE11		*Pwr. Entry & Cable Ladders (27" Cab)*		1/Cab	
	P-OPE11		Pwr. Entry Panel (70/77" Cab)		1/Cab	
PHASE REF XFMR	P-PRT11		LE Phase REF XFMR 120 V 60HZ		1/Cab	
	P-PRT12		LE Phase REF XFMR 220 V 50HZ		1/Cab	
	P-PRT21		LE Phase REF XFMR 120 V 60HZ		1/Cab	
	P-PRT22		LE Phase REF XFMR 220 V 50HZ		1/Cab	
IS BARRIER OPTION	P-ISB12		PTB IS Barriers and Box		1/CCFA	
	P-ISB13		FM IS Barriers and Box		1/CCFA	
	P-ISB14		CSA IS Barriers and Box		1/CCFA	
	P-ISB15		BASEEFA IS Barriers and Box		1/Cab	
BASE	51303012-001		Cabinet Floor Base			

* Round Up

TABLE 4 – Regulator and IBI Cards

Name	Description
Regulator Card	There are two types of regulator cards (B1 and B2). The B1 type provides regulated 5 Vdc and 24 Vdc outputs, and is used in Point Card File Assembly PF100. The B2 type provides regulated 5 Vdc, +15 Vdc, and 24 Vdc outputs and is used in Point Card File Assembly PF200.
IBI (I/O bus Interface) Card	Interface between point file cards and controller file IBC card to allow data and status information to be routed between point file cards and controller file internal bus. Also contains nine LED's mounted at card edge which provide a visual indication of the status of the optional A/O converter on the IBI card, and the status of point card 1 through point card 8. Also contains two connectors which allow I/O bus connections to be made with IBC card in controller card file and IBI card in point card file No.2.

TABLE 5 – Point Card 1 – Point Card 8 Cards

Card Type	Model No.	Input/Output Points/Card	Comments
Analog Input	PXIA12	8 Input Points	1-5V input range and standard 100 ms filter for each input point.
	PXIA22	8 Input Points	4-20 mA input range and standard 100 ms filter for each input point; no power source for transmitter.
	PXIA32	8 Input Points	4-20 mA input range and standard 100 ms filter for each input point; power source for transmitter.
Analog Output	PXOA21	4 Output Points	4-20 mA range for each output point
Digital Input	PXID11	16 Input Points	1 ms filter and 24V input circuit power source for each input point.
	PXID21	16 Input Points	24 ms filter and 24V input circuit power source for each input point.
	PXID31	16 Input Points	1 ms filter and 48V input circuit power source for each input point.
	PXID41	16 Input Points	24 ms filter and 48V input circuit power source for each input point.
Digital output	PXOD31	8 Output Points	Relay output rated at a maximum of 125V, 0.4A for each output point.
	PXOD41	8 Output Points	Solid-state contact point output rated at a maximuim of 30 Vdc, 100 mA for each output point.
Counter Input	PXIP11	4 Input Points	16 ms filter and maximum count rate of 30 counts per second for each counter input.
	PXIP21	4 Input Points	0.1 ms high speed filter and maximum count rate of 2000 counts per second for each counter input.
	PXIP41	4 Input Points	Max count rate 4000 counts per second.

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3760 SILVER STAR ROAD
ORLANDO, FLORIDA 32808
(305) 299-7317

BURNERS • OIL • MEDIUM PRESSURE ATOMIZING

Select the *next larger* burner size above the peak capacity expected. Burner capacities are rated at 40 PSIG for the atomizing air, and oil with a resistance plate, even though design pressures of 125 PSIG can be withstood. Refer to the following section on Recommended Operating Practices on oil metering valves and resistance plates.

A burner selected for 100 GPH @ 40 PSIG peak rating might normally operate at 70 GPH @ 20 PSIG. A turndown rate of 5:1 would give 20 GPH @ 1½ PSIG. There is no problem with burner stability at these lower oil pressures, however, higher oil pressures allow better oil flow control capabilities.

Atomizing air is designed for 0.8 SCFM per one (1) GPH oil capacity @ 40 PSIG. This includes a reserve air capacity for flame shape control on heavier oils of higher viscosity. Typical operation is 0.6 SCFM per one (1) GPH for oils at or below 150 SSU.

The following number describes the burner for ordering and performance information.

03F - GS - 9B - SPC

03F - Oil burner series designation. Reference Bulletin No. 03F.
G - Burner model size. Reference Table 3.
S - Burner model style. Reference Fig. 5 and Table 6.
9 - Burner capacity rating in MM BTU/Hr. Reference Table 3.
B - Burner ball venturi end. Blank if not utilized.
SPC - Special burner requirements. Blank if standard.

EXAMPLE: Select a sealed-in burner for underport firing, and operating at a maximum of 40 GPH. The sequence for burner selection is:

1. 03F - Oil burner only. Reference Bulletin No. 03F.
2. 6 - For a capacity of 40 GPH, the next larger size is 43 GPH. The burner capacity rating for 43 GPH is 6. Units are given in MM BTU/Hr. Reference Table 3.
3. G - This burner model size corresponds to the particular nozzle size. Reference Table 3.
4. E - The elongated version of this burner. Suitable for the longer lengths required between the burner tile and burner mounting bracket with underport firing. Reference Figure 5 and Table 6.
5. B - A sealed-in oil burner requires a burner ball venturi end.
6. Burner Model No. 03F-GE-6B.

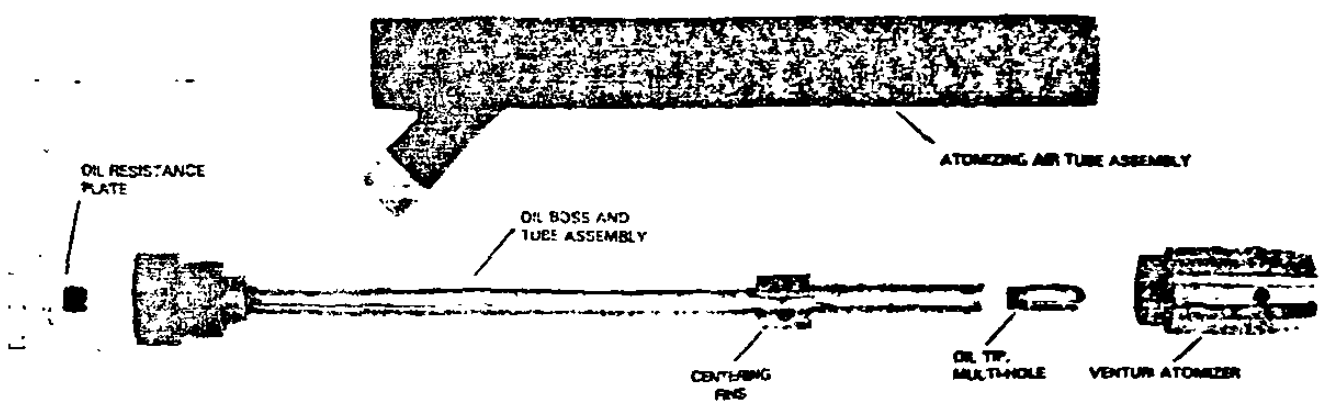

FIG. 2 - DISASSEMBLY OF OIL BURNER (DUAL FUEL TYPE)

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ORLANDO, FLORIDA 32803
(305) 299-7317

BURNERS • OIL • MEDIUM PRESSURE ATOMIZING

TABLE 3 - CAPACITY SELECTION - OIL

BASIC BURNER SIZE (1)	MAXIMUM OIL CAPACITY MM BTU/HR	COMBUSTION AIR FROM REGENERATOR OR RECUPERATOR SCFH (2)	MAXIMUM OIL CAPACITY GPH @ 40PSIG (3)	ATOMIZING AIR SCFM @ 40PSIG (4)	REVERSE TIP COOLING AIR SCFM @ 2PSIG (5)
S	2	21,700	14	11	2
S	2.5	27,900	18	14	3
G	3	34,100	22	18	4
G	4.5	51,100	33	26	6
G	6	66,600	43	34	8
G	9	101,000	65	52	12
M (G)	12	135,000	87	70	16
M (G)	15	167,000	108	86	19
M (G)	18	201,000	130	104	23
M	21	236,000	152	122	27
M	24	268,000	173	138	31
B (M)	24	268,000	173	138	31
B (M)	27	302,000	195	156	35
B (M)	30	336,000	217	174	39
B	33	369,000	238	190	42
B	36	403,000	260	208	47
B	42	470,000	303	242	54
L	42	470,000	303	242	54
L	48	538,000	347	278	62
L	54	604,000	390	312	70
L	60	671,000	433	346	77
L	66	739,000	477	382	85

Notes to Table 3.

1. For oil firing only, use basic burner size designated by the first letter. For dual fuel firing, oil capacity must be compatible with gas capacity; use the best basic burner size letter designation, either first or second letter.
2. Combustion air based on 1409 cubic feet of air at 60°F per gallon of oil. Includes 10% excess air.
3. Oil flow in GPH based on MM BTU/HR rating at approximately 138,000 BTU per gallon of oil. Reference the following section on recommended operating practices for details on the oil pressure resistance plate and oil inlet flow control valve.
4. Atomizing air requirements based on 0.8 SCFM per one (1) GPH oil. Reference the following section on Recommended Operating Practices for application.
5. Reverse tip cooling air listed is typical for reversal furnaces. Reference the following section on Recommended Operating Practices.

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BURNERS • OIL • MEDIUM PRESSURE ATOMIZING

TABLE 4 - BURNER PARTS LIST

Item No.	Req'd	Description
1	1	Oil tip, multi-hole
2	1	Oil tip, single-hole
3	1	Venturi atomizer
4	1	Atomizing air tube assembly
5	1	Oil resistance plate
6	1	Oil boss and tube assembly

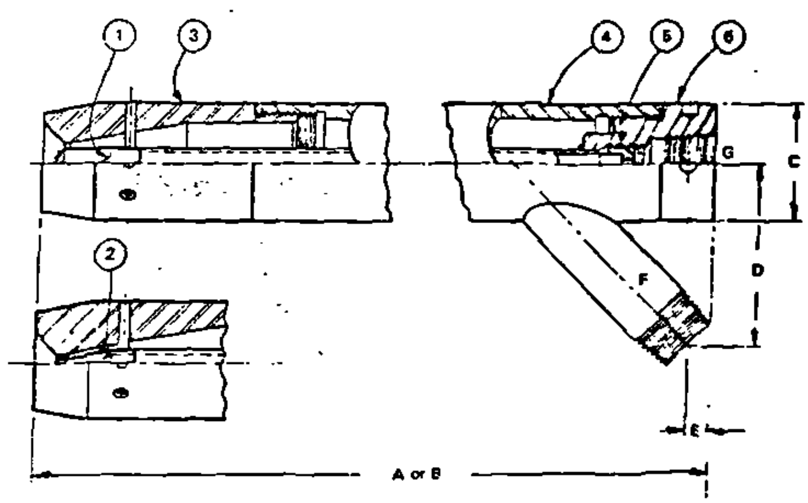


FIG. 5 - BURNER DIMENSION DRAWING

TABLE 6 - BURNER TABLE OF DIMENSIONS AND WEIGHTS

LETTER	DESCRIPTION	S	G	M	B	L
A	Overall burner length, "E" style (1)	24"	25"	26"	28"	29"
B	Overall burner length, "S" style (1)	14"	15"	16"	18"	19"
C	Atomizing air tube assembly diameter	1¼"	1⅜"	1⅝"	1⅞"	2"
D	Burner body centerline to atomizing air inlet centerline	2"	2¼"	2½"	3"	3¼"
E	Burner end to atomizing air inlet centerline	½"	½"	9/16"	⅝"	⅝"
F	Atomizing air inlet, I.P.S.	⅜"	½"	¾"	1"	1¼"
G	Oil inlet, N.P.T.	⅜"	⅜"	⅜"	½"	½"
H	Burner weight, "E" style, lbs.	5	6	9	12	15
J	Burner weight, "S" style, lbs.	3	4	5	7	10

Notes to Table 6:

Thermocouples

Quality Control

All Gordon thermocouple products are manufactured under rigid quality controls. Gordon's Quality Assurance system is established in accordance with MIL-Q-9858. In addition, all emf vs. temperature calibration procedures follow one or more of the following standards:

ASTM E 207 (ANSI Approved)
ASTM E 220 (ANSI Approved)
NBS Circular 590

All testing has NBS traceability. Unless otherwise specified, all Serv-Rite thermocouple wire and extension wire are supplied to meet Standard Tolerances of ANSI Circular MC96.1-1982. Special Tolerances per ANSI MC96.1 are also available at an extra charge.

Initial Calibration Tolerances for Thermocouples

Reference Junction 0°C (32°F)

Thermocouple Type	Temperature Range °C	Temperature Range F	Tolerances † Standard (whichever is greater)	Tolerances † Special (whichever is greater)
B	870 to 1700	1598 to 3092	±0.5%	
E	0 to 900	32 to 1652	±1.7°C or ±0.5%	±1.0°C or ±0.4%
J	0 to 750	32 to 1382	±2.2°C or ±0.75%	±1.1°C or ±0.4%
K	0 to 1250	32 to 2282	±2.2°C or ±0.75%	±1.1°C or ±0.4%
R or S	0 to 1450	32 to 2642	±1.5°C or ±0.25%	±0.6°C or ±0.1%
T	0 to 350	32 to 662	±1.0°C or ±0.75%	±0.5°C or ±0.4%
	Cryogenic Ranges			
E*	−200 to 0	−328 to 32	±1.7°C or ±1%	**
K*	−200 to 0	−328 to 32	±2.2°C or ±2%	**
T*	−200 to 0	−328 to 32	±1.0°C or ±1.5%	**
N	0 to 1250	32 to 2282	±2.2°C or ±0.75%	±1.1°C or ±0.4%

**Thermocouples and thermocouple material are normally supplied to meet the tolerances specified in the table for the normal specified range. The same materials, however, may not fall within the cryogenic tolerances in the second section of the table. If materials are required to meet the cryogenic tolerances, the purchase order must so state. Selection of materials usually will be required. Tolerances indicated in this table are not necessarily an indication of the accuracy of temperature measurements in use after initial heating of the materials.*

***Little information is available to justify establishing special tolerances for cryogenic temperatures. Limited experience suggests the following tolerances for types E and T thermocouples:*

Type E −200 to 0°C ±1.0°C or ±0.5% (whichever is greater)
Type T −200 to 0°C ±0.5°C or ±0.8% (whichever is greater)

These tolerances are given only as guide for discussion between purchaser and supplier. Due to the characteristics of the materials, cryogenic tolerances for Type J thermocouples and special cryogenic tolerances for Type K thermocouples are not listed.

†Where tolerances are given in percent, the percentage applies to the temperature being measured in degrees Celsius. For example, the standard tolerance of Type J over the temperature range 277° to 750°C is ±0.75 percent. If the temperature being measured is 538°C, the tolerance is ±0.75 percent of 538, or ±4.0°C. To determine the tolerance in degrees Fahrenheit, multiply the tolerance in degrees Celsius times 1.8.

ANSI Letter Designations

Thermocouple and extension wires are now generally ordered and specified by ANSI letter designations for wire type. Positive and negative legs are identified by the appropriate letter suffixes P and N, respectively.

ANSI Letter	Description	Popular Generic & Trade Names*
T	TP	Copper
	TN	Constantan, Cupron, Advance
J	JP	Iron
	JN	Constantan, Cupron, Advance
E	EP	Chromel, Tophel T_1
	EN	Constantan, Cupron, Advance
K	KP	Chromel, Tophel, T_1
	KN	Alumel, Nial, T_2
R	RP	Platinum 13% Rhodium
	RN	Pure Platinum
S	SP	Platinum 10% Rhodium
	SN	Pure Platinum
B	BP	Platinum 30% Rhodium
	BN	Platinum 6% Rhodium
N	NP	Nicrosil
	NN	Nisil

**Trade Names: Cupron, Nial and Tophel—AMAX • Advance, T1, and T2—Harrison Alloy Co. • Chromel and Alumel-Hoskins Mfg. Co.*

Thermocouple Selection

Thermocouples must be selected to meet the conditions of the application. Only general recommendations on size and type can be given. Some of the considerations involved are length of service, temperature, atmosphere and desired response time. The temperature ranges of the commonly used thermocouple types are given in the Initial Calibration Tolerances Table. Smaller gauge sizes provide faster response at the expense of service life at the elevated temperatures. Larger gauge sizes provide longer service life at the expense of response time. See ANSI Circular MC96.1. As a general rule, it is advisable to protect thermocouple elements with a suitable protecting tube or drilled well.

When ordering thermocouple wire or elements, be certain that the type (K, J, E, etc.) corresponds to that of the instrument with which it will be used. This information can usually be found on the face of the instrument.

ANSI Type E: The Chromel-Constantan thermocouple is suitable for use at temperatures up to 1652° F (900° C) in a vacuum, inert, mildly oxidizing or reducing atmosphere. At cryogenic temperatures, the thermocouple is not subject to corrosion. This thermocouple has the highest EMF output per degree of all the commonly used thermocouples.

ANSI Type J: May be used, protected or unprotected, where there is a deficiency of free oxygen but, again for cleanliness and generally longer life, a protecting tube is recommended. Since JP (Iron) wire will oxidize rapidly at temperatures over 1000°F (538°C), it is recommended that larger gauge wires be used to compensate. Maximum recommended operating temperature is 1400°F (760°C).

ANSI Type K: Due to its reliability and accuracy, Type K is used extensively at temperatures up to 2300°F (1260°C). It is good practice always to protect this type of thermocouple with a suitable metal or ceramic protecting tube, especially in reducing atmospheres. In oxidizing atmospheres, such as electric furnaces, tube protection is not always necessary when other conditions are suitable; however, it is recommended for cleanliness and general mechanical protection. Type K will generally outlast Type J because the JP (Iron) wire rapidly oxidizes, especially at the higher temperatures. Standard wire finishes are 14 B & S gauge and larger, oxidized; 16 B & S gauge and smaller, bright annealed.

ANSI Type N: Nicrosil/Nisil nickel-based thermocouple alloy used primarily at high temperature (up to 2300°F). While not a direct replacement for Type K, Type N provides better resistance to oxidation at high temperature and longer life in applications where sulfur is present. It also outperforms Type K in K's aging range.

ANSI Type T: This thermocouple can be used in either oxidizing or reducing atmospheres but for cleanliness and generally longer life, a protecting tube is recommended. Because of its stability at lower temperatures, this is a superior thermocouple for a wide variety of applications in low and cryogenic temperatures. Operating range—328 to 662°F (-200 to 350°C) but can be used to -452°F (-269°C) (boiling helium).

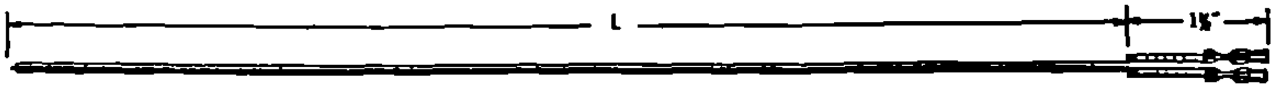
ANSI Types S, R and B: Maximum recommended operating temperature for type S or R is 2642°F (1450°C), type B is recommended for use at as high as 3092°F (1700°C). These thermocouples are easily contaminated. Reducing atmospheres are particularly damaging to the calibration. Noble metal thermocouples should always be protected with gas-tight Serv-Rite ceramic tubes, a secondary tube of porcelain, and silicon carbide or metal outer tubes as conditions require. **Types S and R thermocouples and thermoelements are provided in accordance with IPTS-48, unless IPTS-68 is specifically requested. Type B thermocouples and thermoelements meet both IPTS-48 and IPTS-68.**

Tungsten 5% Rhenium/Tungsten 26% Rhenium: This refractory metal thermocouple may be used at temperatures up to 4200°F (2315°C). As it has no oxidation resistance its use is restricted to vacuum, hydrogen or inert atmospheres.

Note: Temperatures are in relation to table # 7, page 15, of ANSI MC96 1, August, 1982.

Gordon
Temperature Measurement

ANSI Type S, R or B



Elements with Insulators

Shown with optional MC-124 copper sleeves.

Cat. No.*	Diameter	Length
2110	.0201"—24 B&S Ga. Bare	12" through 48" in 6" increments
†2111	.0201"—24 B&S Ga. Ceramic Insulated §	
2112	.0225"—23 B&S Ga. Bare	
†2113	.0225"—23 B&S Ga. Ceramic Insulated §	
†2114	.0201"—24 B&S Ga. Alumina Insulated §	
†2115	.0225"—23 B&S Ga. Alumina Insulated §	
†2116	.0100"—30 B&S Ga. Ceramic Insulated §	
†2117	.0100"—30 B&S Ga. Alumina Insulated §	

*Specify Type S, R or B by adding -S, -R or -B after the catalog number. Types S and R thermocouples and the thermoelements are provided in accordance with IPTS 48, unless IPTS-68 is specifically requested. Type B thermocouples and thermoelements meet both IPTS-48 and IPTS-68. Note Type B is available in 24 gauge only.

†For use with standard, general purpose heads, platinum assemblies can be furnished with MC-124 copper sleeves, no additional charge.

§Insulation consists of a one-piece two-hole ceramic (Cat. No. 333) or alumina (Cat. No. 391) insulator. Over 24" lengths, a single piece ceramic or alumina 3/16" diameter insulator is used.

To order, specify: 2111-R-24
- R — Calibration
- 24 — Length

Temperature Limit Fuses

GOLD-Melting Point 1945° F (1063° C)

Cat. No.	B & S Gauge	Length
402	20	12" and over, in 6" increments

SILVER—Melting Point 1760° F (960° C)

Cat. No.	B & S Gauge	Length
412	20	12" and over, in 6" increments

To order, specify: 402-18
- 18 — Length in inches

Immersion Tips

Cat. No.	Length of tip inches	Length of Lance
1449-501-T	8	31", 43", 55", 72", 96" and 120" only. Specify when ordering.
1449-M-12	12	
1449-M-15	15	
1449-M-18	18	
1449-M-20	20	
1449-M-24	24	
1449-M-30	30	

Serv-Rite immersion tips are superior thermocouples for nonferrous molten metals. The hot junction is forged into the 446 stainless steel sheath for maximum sensitivity. They are available in Type K calibration only. They are designed for use with Gordon XacTemp® Pyrometers but also can be used with many other instruments.

To order, specify: 1449-501-T-8-43
- 43 — Length of lance
- 8 — Length of tip

Base Metal Thermocouple Assemblies—90° Angle Type

Cold Leg 18" Long, Fixed Elbow and TH-2700 Series head are standard§

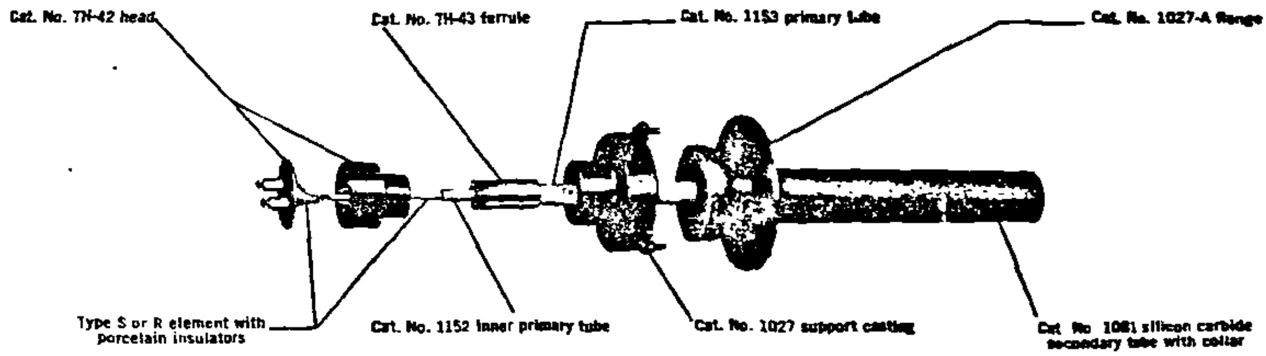
Typical Angle Type Assemblies

ANSI TYPE K Cat. No.	ANSI TYPE J Cat. No.	B&S Gauge	PROTECTING TUBE (Hot Leg) Material	NPT Size	Construction	HEAD§	HOT LEG LENGTH
1415-1377	1518-1377	14	Cast Iron	1"	Cast	TH-2704-A	12" through 48" in 6" increments.
1414-1377	1517-1377	8	Cast Iron	1"	Cast	TH-2704-A	
1415-1375	1518-1375	14	Cast Iron	¾" Int	Cast	TH-2705-A	12" through 72" in 6" increments.
1414-1375	1517-1375	8	Cast Iron	¾" Int	Cast	TH-2705-A	
1415-1326	1518-1326	14	Black Steel	½"	Welded	TH-2706-A	12" and over, in 6" increments.
1415-1328	1518-1328	14	Black Steel	1"	Welded	TH-2704-A	
1414-1328	1517-1328	8	Black Steel	1"	Welded	TH-2704-A	
1415-1307	1518-1307	14	446SS	½"	Seamless	TH-2706-A	12" and over, in 6" increments.
1414-1307	1517-1307	8	446SS	½"	Seamless	TH-2706-A	
1414-1308	1517-1308	8	446SS	¾"	Seamless	TH-2705-A	
1414-1309	1517-1309	8	446SS	1"	Seamless	TH-2704-A	
1415-1395	1518-1395	14	Alloy 601	½"	Seamless	TH-2706-A	12" and over, in 6" increments.
1414-1395	1517-1395	8	Alloy 601	½"	Seamless	TH-2706-A	
1414-1396	1517-1396	8	Alloy 601	¾"	Seamless	TH-2705-A	
1414-1397	1517-1397	8	Alloy 601	1"	Seamless	TH-2704-A	

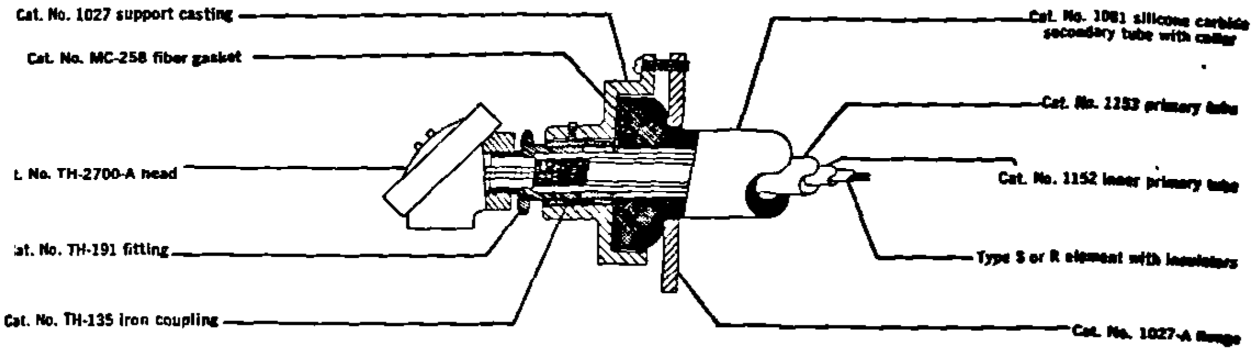
§Cold Leg Lengths over 18" long; Universal Elbow; Vent; and LA or LI Series Universal heads may be substituted on request.

To order, specify: catalog number—length   Example: 1414-1395-24

Noble Metal Thermocouple Assemblies



Typical Noble Metal Assembly
With TH-42 Head



Typical Noble Metal Assembly
With TH-2700-A or LA Series Head

With TH-42 Head and All Porcelain Ceramics*

Cat No †	B&S Gauge	Protecting Tubes	Size I.D. x O.D.	Length
2100	24	1153 Primary only	7/16" x 11/16"	12" through 48" in 6" increments
2101	24	1153 Primary 1152 Inner Primary	1/4" x 11/16"	
2102	24	1153 Primary 1152 Inner Primary 1081 Secondary	1/4" x 1 3/4"	
2103	24	1153 Primary 1081 Secondary	7/16" x 1 3/4"	

With Series TH-2700-A Head§ and All Porcelain Ceramics*

Cat. No.†	B&S Gauge	Protecting Tubes	Size I.D. x O.D.	Length
2130	24	1153 Primary only	7/16" x 11/16"	12" through 48" in 6" increments
2131	24	1153 Primary 1152 Inner Primary	1/4" x 11/16"	
2106	24	1153 Primary 1152 Inner Primary 1081 Secondary	1/4" x 1 3/4"	

With TH-42 Head and Alumina Ceramics*

Cat. No.†	B&S Gauge	Protecting Tubes	Size I.D. x O.D.	Length
2140	24	1147 Alumina Primary only	7/16"x11/16"	12" through 48" in 6" increments
2141	24	1147 Alumina Primary 1146 Alumina Inner Primary	1/4"x11/16"	
2142	24	1147 Alumina Primary 1146 Alumina Inner Primary 1081 Secondary	1/4"x1 3/4"	
2143	24	1147 Alumina Primary 1081 Secondary	7/16" x 1 3/4"	

With Series TH-2700-A Head§ and Alumina Ceramics*

Cat. No.†	B&S Gauge	Protecting Tubes	Size I.D. x O.D.	Length
2144	24	1147 Alumina Primary only	7/16"x11/16"	12" through 48" in 6" increments
2145	24	1147 Alumina Primary 1146 Alumina Inner Primary	1/4"x11/16"	
2147	24	1147 Alumina Primary 1146 Alumina Inner Primary 1081 Secondary	1/4"x1 3/4"	

To order, specify: catalog number—length of tube calibration—length

Example: 2103-S-12

- 12 — Length of tube
- S — Calibration

*Above 2400° F (1316° C) assemblies using Alumina ceramics are recommended. All porcelain ceramic assemblies use Cat. No 2111 elements. Alumina ceramic assemblies use Cat. No. 2114 elements.

†Specify Type S, R or B by adding -S, -R or -B after the catalog number. Types S and R thermocouples and thermoelements are provided in accordance with IPTS-48, unless IPTS-68 is specifically requested. Type B thermocouples and thermoelements meet both IPTS-48 and IPTS-68.

§ Series Aluminum head may be substituted on request.

ISOLATED, TWO-WIRE, 4-20 MA THERMOCOUPLE TRANSMITTER

NEWPORT

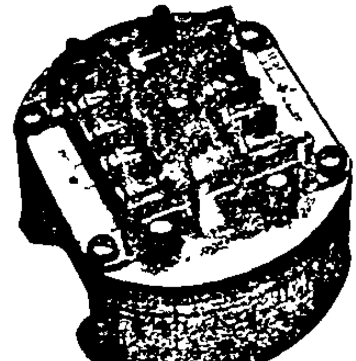
MODEL 502A

STANDARD FEATURES

- 1500 V rms input/output isolation
- Input from type J, K, E, T, R, S or B thermocouples
- 4-20 mA full-scale output
- Two-wire operation with 9 to 50 V compliance
- One model for each T/C type covers all ranges
- Narrow span capability:
  - 50°C (90°F) for type T
  - 100°C (180°F) for types J, K, E
  - 250°C (450°F) for types R, S
  - 350°C (630°F) for type B
- Field-selectable zero suppression over full T/C range
- –40 to +85°C (–40 to +185°F) operating temperature with rated accuracy
- Upscale or downscale open-thermocouple indication
- Input and output protection to 120 V ac
- Compact 74 mm (2.9 in) diameter die-cast metal housing
- Waterproof to 35 kPa (5 psi)
- 55 g shock resistance

OPTIONS

- Six mounting methods
- Insulating case-top cover
- External explosion-proof housings
- Companion loop-powered indicator (Model 508A)



DESCRIPTION

Model 502A is an isolated, two-wire 4-20 mA transmitter which can be ordered for NBS thermocouple types J, K, E, T, R, S or B. It provides a unique combination of electrical, environmental and mechanical specifications for remote operation in severe industrial environments. Its compliance voltage can be as low as 9 V dc for use with intrinsic-safety barriers, loop monitors and limited supply voltages. Field calibration is easy.

UNMATCHED ELECTRICAL PERFORMANCE

The 502A allows spans as narrow as 50°C (90°F) or as wide as 2000°C (3600°F), depending on thermocouple type and user selection. These spans may be located anywhere from -50°C to the NBS-recommended maximum temperature for each T/C type.

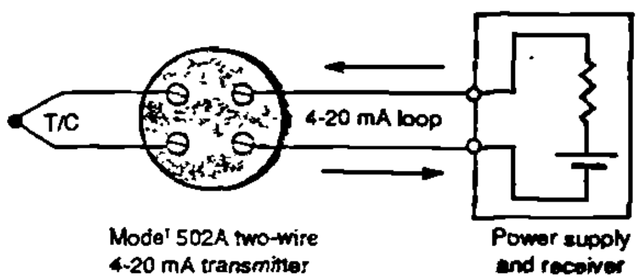
The exceptionally narrow span and large zero suppression capabilities (high turndown ratio) of the 502A allow high-gain control for continuous processes and close conformity to the NBS tables over narrow temperature ranges. The wide span capability of the 502A is ideal for batch processes, which require repeatability over a wide dynamic range. Downstream linearization of the 4-20 mA signal is required for accurate temperature readout over a wide span.

EASY TO CONFIGURE AND CALIBRATE

Both zero suppression and span are fine-tuned with precision 15-turn potentiometers. These are accessible through holes in the die-cast cover, which are normally sealed with fluorosilicone plugs. Coarse zero and span steps are selected by opening the case and changing push-on jumpers.

IDEAL FOR HARSH ENVIRONMENTS

The 502A is rated for operation from –40 to +85°C with specified accuracy. Its case is made of die-cast metal and is waterproof to 5 psi. The electronics are firmly soldered to the top of the case, so that the 502A can withstand high vibration and shock, such as a 6-foot drop onto concrete. A plastic cover with screwdriver holes is standard for protection of the screw-terminal barrier strip. An insulating cover for the top of the case is optional and can provide additional protection from wind and sun.



The 502A utilizes the power-supply leads as signal leads. This simplifies field wiring by eliminating separate power and signal leads.

THERMOCOUPLE TYPE	MINIMUM TEMPERATURE (for 4 mA output)	MAXIMUM TEMPERATURE (for 20 mA output)	ZERO SUPPRESSION (for 4 mA output)	TEMPERATURE SPAN (for 4-20 mA output)
Type J (Iron-Constantan)	−50°C	+760°C	−50 to +660°C	100 to +810°C
	−58°F	+1400°F	−58 to +1220°F	180 to +1458°F
Type K (Chromel-Alumel)	−50°C	+1372°C	−50 to +1272°C	100 to +1422°C
	−58°F	+2502°F	−58 to +2322°F	180 to +2560°F
Type T (Copper-Constantan)	−50°C	+400°C	−50 to +350°C	50 to +400°C
	−58°F	+752°F	−58 to +662°F	90 to +720°F
Type E (Chromel-Constantan)	−50°C	+1000°C	−50 to +900°C	100 to +1050°C
	−58°F	+1832°F	−58 to +1652°F	180 to +1836°F
Type R (Pt, 10% Rh – Pt)	−50°C	+1768°C	−50 to +1500°C	250 to +1800°C
	−58°F	+3214°F	−58 to +2732°F	450 to +3240°F
Type S (Pt, 13% Rh – Pt)	−50°C	+1768°C	−50 to +1500°C	250 to +1800°C
	−58°F	+3214°F	−58 to +2732°F	450 to +3240°F
Type B (Pt, 30% Rh – Pt, 6% Rh)	0°C	+1820°C	−50 to +1500°C	350 to +1900°C
	32°F	+3308°F	−58 to +2732°F	630 to +3420°F

EXPLOSION-PROOF HOUSING OPTIONS

Three external NEMA-7 explosion-proof and NEMA-4 waterproof enclosures are available as options for use in hazardous locations in Class I, Groups B, C, D; and Class II, Groups E, F, G.

Option EPH is a single-height, all-metal housing for a *single 500-Series transmitter.*

Option EPH1 is an upgraded version of EPH which adds FM and CENELEC certification.

Option EPW2 is a double-height metal enclosure with a glass window for a 500-Series transmitter on the bottom and a 508A loop-powered indicator on top. FM and CENELEC certification are standard. The 508A augments the transmitter with an LCD digital readout scaled in engineering units and only adds a modest 2.5 V drop to the current loop.

SPECIFICATIONS

SIGNAL INPUT

Input resistance .... 5 MΩ
Bias current, max .... 50 nA
T/C lead resistance ..... 100 Ω, specified performance; 10 kΩ max

NOISE REJECTION

NMR .... 60 dB, 50/60 Hz, 100 mV input
CMR .... 100 dB, DC to 60 Hz
Power supply rejection, min .... 0.01% of span/volt

INPUT/OUTPUT PROTECTION

CMV, input to case or output ...... 2100 Vp per HV test, 354 Vp per IEC spacing
NMV, across input leads .... 120 V ac for 1 min
NMV, across output leads .... 120 V ac for 1 min
Reverse polarity across output leads .... 400 Vp

SIGNAL OUTPUT

Current output, linear range .... 4 to 20 mA
Current output, max .... 35 mA
Supply compliance .... 9 to 50 V
Open-thermocouple indication:
- Standard .... Upscale overrange (over 25 mA)
- Optional .... Downscale overrange (under 3.8 mA)

Step response time 0-98% (four time constants):
- At low gain (wide input span) .... 17 ms
- At high gain (narrow input span) .... 120 ms

ACCURACY FROM −40 TO +85°C

Repeatability error .... ±0.2°C ±0.1% of span
T/C conformity error:
- 100°C span .... ±1°C for J, K; ±1.5°C for E, T
- 250°C span (> 600°C) .... ±1.5°C for R,S
- 350°C span (>1200°C) .... ±2°C for B

6-month stability error: ±0.2°C ±0.2% of zero suppression
Errors due to 50°C change in transmitter temperature:
- Zero error:
  - J, K, E, T ...... ±0.5°C ±0.2% of zero suppression
  - R, S, B .... ±1°C ±0.2% of zero suppression
- Span error .... ±0.2% of span

ENVIRONMENTAL

Operating temperature with rated accuracy .. −40 to +85°C
Storage temperature .... −55 to +125°C
Relative humidity .... 0% to 100% (sealed case)
Watertight proof pressure .... 35 kPa (5 psi)
Vibration .... 1.52 mm (.06 in) double amplitude, 10-80 Hz cycled
Shock .... 55 g, half-sine, 9-13 msec duration

MECHANICAL

Case material .... Zamak® zinc alloy
Gasket material .... Fluorosilicone
Diameter .... 74 mm (2.9 in)
Height, including barriers .... 52 mm (2.1 in)
Weight .... 380 g (13 oz)
Connections .... #6 screws with wire clamps
Terminal protection ... Screw-terminal barriers (standard)
Barrier-strip cover (standard)
Insulating case-top cover (optional)

SCREW-TERMINAL PIN ASSIGNMENT

1	TEST	A	N/C
2	+ PWR /OUTPUT	B	+ TC
3	- PWR/OUTPUT	C	- TC
4	CASE GND	D	N/C

MOUNTING METHODS

See Mechanical section for mounting drawings.

1. Surface mount with four #6 rear-entry screws. Tapped holes are provided in back of case. Screws are inserted from backside of bulkhead.
2. Snap mount into 63.5 mm (2.50 in) relay track.
3. Surface mount with two #8 front-entry screws. Requires optional MAT1 adapter-plate.
4. Snap mount into 69.9 mm (2.75 in) or 76.2 mm (3.00 in) relay track. Requires optional MAT1 adapter plate.
5. Snap mount into DIN relay track per CENELEC standard EN 50 022. Requires optional MDT1 rail clamp.
6. Push mount into optional external waterproof or explosion-proof housings EPH or EPW2. Includes MXS1 spring retainers.

ORDERING GUIDE

Make a maximum of one entry per box and separate by commas. An asterisk "*" requires no entry. Example: 502A-J, FS, CBP1, 0°C = 4 mA, 400°C = 20 mA

☐ -502A **4-20 mA THERMOCOUPLE TRANSMITTER**

☐ — **THERMOCOUPLE TYPE**

Temperature ranges in parentheses are factory-set default for 4-20 mA output.

J	Type J	(0 - 500°C)
K	Type K	(0 - 800°C)
T	Type T	(0 - 400°C)
E	Type E	(0 - 500°C)
R	Type R	(500 - 1500°C)
S	Type S	(500 - 1500°C)
B	Type B	(800 - 1800°C)

☐ — **OPEN-THERMOCOUPLE INDICATOR**

*	Upscale overrange (over 25 mA)
DS	Downscale overrange (under 3.8 mA)

☐ — **MOUNTING CONFIGURATION**

*	Case alone for surface mount with rear-entry screws, for snap mount into 63.5 mm (2.50 in) relay track, or for mounting in explosion proof housing.
MAT1	Adapter plate for surface mount with front-entry screws, or snap mount into 69.9 mm (2.75 in) or 76.2 mm (3.00 in) relay track.
MDT1	Rail clamp for snap mount into DIN relay track.

ADD-ON OPTIONS

☐ -FS	Custom scaling. Specify temperatures corresponding to 4 mA and 20 mA.
☐ -CBP1	Insulating cover for case top.
☐ -EPH	External single-height environmental enclosure rated NEMA-7 (explosion-proof) and NEMA-4 (waterproof). Includes MXS1.
☐ -EPH1	Version of EPH with FM and CENELEC EEx d II C certification.
☐ -EPW2	External double-height environmental enclosure with window for one 500-Series transmitter (on bottom) and one Model 508A loop-powered indicator (on top), for indicating two-wire 4-20 mA transmitter applications. Rated NEMA-7 (explosion-proof) and NEMA-4 (waterproof). Includes FM and CENELEC EEx d II C certification and internal mounting hardware.
☐ -MXS1	Spring retainers for customer-furnished explosion-proof housing.

IFOA DIMENSIONAL DATA

Tables 2, 3, 4, and 5 list IFOA orifice and pipe diameters for standard and nonstandard configurations, and for situations when the associated piping is provided by either Foxboro or the user. The Beta ratios (β) are also given for each configuration.

Table 2. Actual IFOA Pipe Inside Diameter (ID)

Orifice Assembly Size	Associated Piping		Pipe Supplied By Foxboro Bored Pipe ID(1)		Pipe Supplied By User Standard Pipe ID(2)	
	Size	Schedule	mm	in	mm	in
1/2	1/2	40	16.76	0.660	15.80	0.622
1	1	40	27.76	1.093	26.64	1.049
1 1/2	1 1/2	80	39.65	1.561	38.10	1.500

(1)When associated piping is supplied by Foxboro, ID of both ends of pipe at orifice assembly is precision bored to indicated diameter.
(2)When pipe is supplied by user, nominal ID of commercial pipe is listed.

**Table 3.
Standard and Nonstandard IFOA Orifice Bore Diameters
(For Corresponding Beta Ratios (β), See Tables 4 and 5)**

Type Orifice Plate		Orifice Bore Diameters for the Following Orifice Assembly Size					
		1/2 in		1 in		1 1/2 in	
		mm	in	mm	in	mm	in
With Standard Bore Diameters		0.508	0.0200	6.15	0.242	9.70	0.382
		0.889	0.0350	8.66	0.341	13.67	0.538
		1.524	0.0600	12.14	0.478	19.08	0.751
		2.54	0.100	16.64	0.655	25.86	1.018
		4.06	0.160	21.13	0.832	29.97	1.180
		6.35	0.250	—	—	—	—
		8.89	0.350	—	—	—	—
With Nonstandard Bore Diameters	All Metal(1)	1.676	0.066	2.78	0.109	3.97	0.156
		13.41	0.528	22.21	0.874	31.72	1.249
	Jewel Insert(1)	0.051	0.0020	—	—	—	—
		0.381	0.0150	—	—	—	—

(1)Minimum and maximum sizes listed.

**Table 4
Standard and Nonstandard IFOA Orifice Bore Beta Ratios (β),
Based on Pipe Supplied by Foxboro**

Type Orifice Plate		Beta Ratios for the Following Orifice Assembly Size								
		1/2 in			1 in			1 1/2 in		
		Orifice Bore		Beta Ratio	Orifice Bore		Beta Ratio	Orifice Bore		Beta Ratio
		mm	in		mm	in		mm	in	
With Standard Bore Diameters		0.508	0.0200	0.03030	6.15	0.242	0.2214	9.70	0.382	0.2447
		0.889	0.0350	0.05303	8.66	0.341	0.3120	13.67	0.538	0.3447
		1.524	0.0600	0.09091	12.14	0.478	0.4373	19.08	0.751	0.4811
		2.54	0.100	0.1515	16.64	0.655	0.5993	25.86	1.018	0.6521
		4.06	0.160	0.2424	21.13	0.832	0.7612	29.97	1.180	0.7559
		6.35	0.250	0.3788	—	—	—	—	—	—
		8.89	0.350	0.5303	—	—	—	—	—	—
With Nonstandard Bore Diameters	All Metal	Beta ratios between 0.1 and 0.8 can be supplied								
	Jewel Insert	Beta ratios between 0.00303 and 0.0227			—	—	—	—	—	—

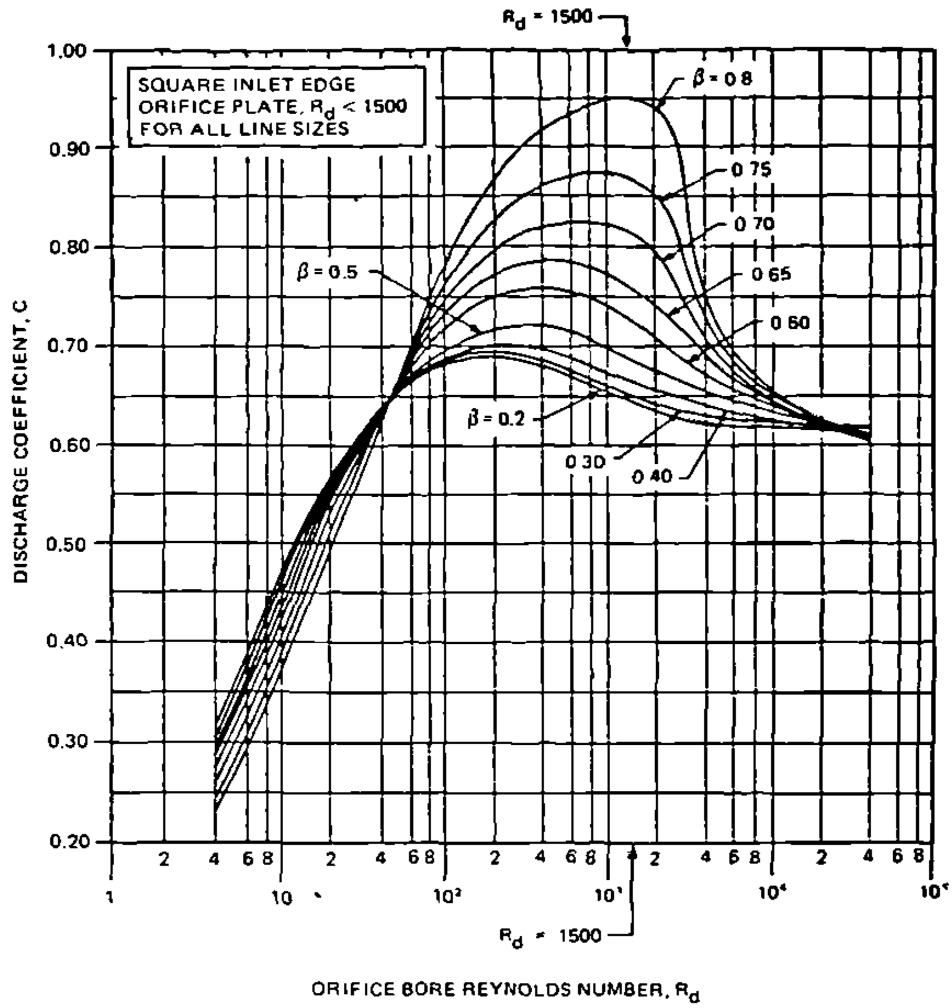


Figure 1
Discharge Coefficient versus Orifice Bore Reynolds Number (below 1500)
for a Square Inlet Edge Orifice Plate
(For All Line Sizes)

SUPPLEMENTAL INFORMATION

Table 19. Gas Properties at Base Conditions

Gas	Molecular Weight M_w	Specific Gravity G	(a)Density, ρ_b lb/ft³	kg/m³
Air (Dry)	28.96	1.000	0.0763	1.222
Ammonia	17.03	0.588	0.0449	0.719
Argon	39.95	1.379	0.1053	1.687
Benzene	78.11	2.697	0.2058	3.297
N-Butane	58.12	2.007	0.1531	2.452
1-Butene	56.10	1.937	0.1478	2.367
Carbon Dioxide	44.01	1.520	0.1160	1.858
Carbon Monoxide	28.01	0.967	0.0738	1.182
N-Deuterium	4.03	0.139	0.0106	0.170
Ethane	30.07	1.038	0.0792	1.269
Ethylene	28.05	0.969	0.0739	1.184
Ethyl Ester	74.12	2.559	0.1953	3.128
Helium	4.00	0.138	0.0105	0.168
N-Heptane	100.21	3.460	0.2640	4.229
N-Hexane	86.18	2.976	0.2271	3.638
Hydrogen	2.02	0.070	0.0053	0.085
Hydrogen Sulfide	34.08	1.177	0.0898	1.438
Isobutane	58.12	2.007	0.1531	2.452
Isopentane	72.15	2.491	0.1901	3.045
Methane	16.04	0.554	0.0423	0.678
Methyl Fluoride	34.03	1.175	0.0897	1.437
Natural Gas(b)	17.38	0.600	0.0458	0.734
Neon	20.18	0.697	0.0532	0.852
Nitric Oxide	30.01	1.036	0.0791	1.267
Nitrogen	28.01	0.967	0.0738	1.182
Oxygen	32.00	1.105	0.0843	1.350
N-Pentane	72.15	2.491	0.1901	3.045
Propane	44.09	1.522	0.1162	1.861
Propene	42.08	1.453	0.1109	1.776

(a)Density at base conditions of 59°F and 14.7 psia (15°C and 101 kPa absolute). To determine density of other gases at any flowing condition, use applicable equation below.
(b)A common natural gas having a specific gravity of 0.6. To determine densities of other natural gases at base conditions, use applicable equation below.

U.S. Customary Units

$$\rho_f = (2.6988)\frac{(G)(\rho_f)}{(Z_f)(T_f)}$$

S.I. Units

$$\rho_f^* = (3.4834)\frac{(G)(\rho_f)}{(Z_f)(T_K)}$$

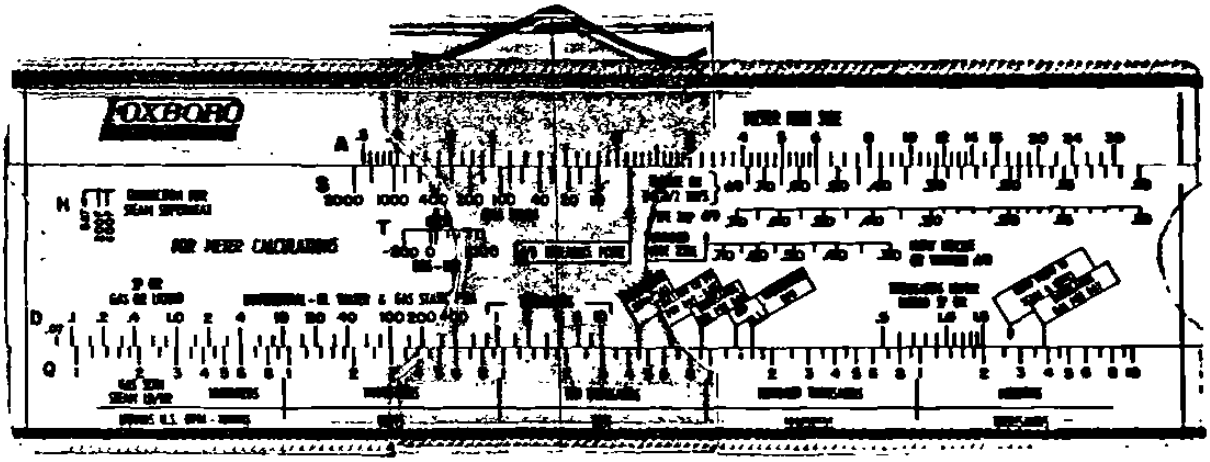
Table 20. Conversion of Units

To Convert	Multiply By	To Obtain
psi	6 895	kPa
bar	100	kPa
kg/cm²	98.07	kPa
inH_2O	0 2487	kPa
mmH_2O	0.009791	kPa
mmHg	0 1333	kPa
inH_2O	0 03606	psi
inHg	0 4912	psi
mmHg	0 01934	psi
kPa	0 1450	psi
IMP gpm	1 201	U S. gpm
L/s	15 85	U.S gpm
ft³/h	0.1247	U.S. gpm
m³/h	4 403	U S gpm
U.S. gpm	8 021	ft³/h
U.S. gpm	0.06309	L/s
m³/h	0.2778	L/s
U.S. gpm	0.2272	m³/h
L/s	3.600	m³/h
lb/h	0 4536	kg/h
m³/h	density (kg/m³)	kg/h
ft³/h	density (lb/ft³)	lb/h
kg/h	2 205	lb/h
centipoise	1/specific gravity	centistokes
centistokes	specific gravity	centipoises
bar gauge + 1 0 bar = bar absolute		
kPa gauge + 101 3 kPa = kPa absolute		
psi gauge + 14 7 psi = psi absolute		
°F + 460 = °R	°C + 273 = K Scale	
°F = (9/5) (°C) + 32	°C = (5/9) (°F - 32)	

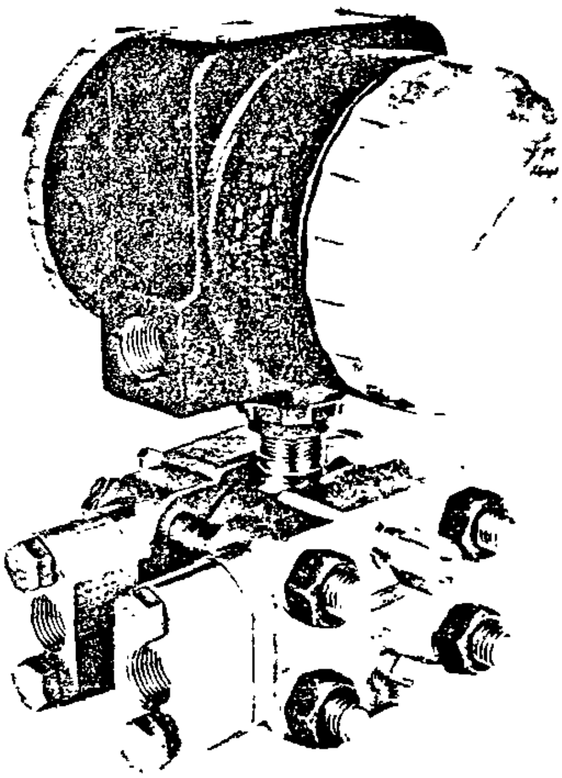
Table 21
Equations for Permanent Pressure Loss Due to Orifice*

Units	Equation
U.S. Customary	$h_l = (1 - 0.24\beta - 0.52\beta^2 - 0.16\beta^3)h_w$
SI	$\Delta P^* = (1 - 0.24\beta - 0.52\beta^2 - 0.16\beta^3)\ \Delta P^*$

*Applicable to liquid, gas, and vapor flow



NOMOGRAMA FOXBORO. Para calculos de Transductores tipo Orificio, y Cv de Valvulas de Control. (Calculo Aproximado).



823DP d/p Cell TRANSMITTER

These 2-wire transmitters provide precision measurement of differential pressure and transmit proportional 4 to 20 or 10 to 50 mA dc signals. A version with frequency output for use with SPEC 200 input components is also available. (Refer to PSS 2A-1A3 B.)

Resonant wire sensor technology provides significant improvement in performance and long-term stability. Modular construction simplifies servicing and helps to reduce spare parts inventory. This unique blend of up-to-date technology and product design, combined with advances in wetted parts materials, provides the process industries with differential-pressure transmitters having a new dimension in versatility.

RADIO-FREQUENCY INTERFERENCE (RFI) PROTECTION

The transmitter output is virtually unaffected by radio frequency signals (walkie-talkies, etc.)

SUPERIOR PERFORMANCE

The 823DP Transmitter provides assured accuracy of ±0.2% of span, repeatability of better than 0.05% of span, and excellent long-term stability. Combine this with minimal ambient temperature, static pressure, and over-range pressure effects and the result is unequalled overal performance.

VOLTAGE SURGE PROTECTION

A power Zener diode (transient voltage suppressor) is included in the terminal compartment of the electronics housing to protect against a voltage surge

ROTATABLE HOUSING

The topworks housing may be easily rotated to any one of four positions. This feature enables the user to position the housing for maximum visibility of the optional indicating meter, easy accessibility to the zero adjustment, or flexibility in locating a conduit run. A positive over-rotation stop prevents accidental damage to the sensor wires.

STATIC PRESSURE RATING

Standard static pressure rating of 20 MPa (3000 psi, or 200 bar or kg/cm²) is 50% higher than most competitive offerings. This satisfies almost all applications with standard construction. Optional 40 MPa (6000 psi, or 400 bar or kg/cm²) rating is also available.

MULTIPLE PROTECTION FROM ENVIRONMENTS

There are two separate compartments in the epoxy-coated aluminum housing. Each compartment has only one access, which is sealed to exclude moisture and corrosive atmospheres. One compartment is for the electronics, and the other is for field connections. This eliminates the need to open the electronics compartment during installation. The electronic circuits are encapsulated in one replaceable module that provides complete moisture protection.

HIGHLY CORROSION-RESISTANT SENSOR DIAPHRAGMS

Standard diaphragm material of cobalt-nickel-chrome alloy provides nearly universal corrosion resistance at no extra cost. This alloy has proven its durability and corrosion resistance as the force bar diaphragm in millions of Foxboro d/p Cell transmitters for over 30 years. For additional information regarding cobalt-nickel-chrome alloy, refer to TI 037-078 and TI 037-75b. Sensor diaphragms of AISI Type 316 stainless steel (316 ss), Hastelloy C-276, Monel, and tantalum are also available for specific application requirements.

STANDARD FEATURES

The 823DP Transmitter includes the following standard features which are normally extra cost options, or not available, with most other brands of transmitters:

- Side Vents and Drains
- Mounting Bracket
- Voltage Surge Protection
- High-strength B7 Alloy Steel Bolting
- Epoxy Finish
- 20 MPa (3000 psi, 200 kg/cm²) Static Pressure Rating
- Corrosion-resistant Cobalt-Nickel-Chrome Alloy Diaphragms

OPERATING AND STORAGE CONDITONS

Operating Conditions

Influence	Reference Operating Conditions	Normal Operating Condition Limits	Storage and Shipping Limits
Sensor Temperature[a]	24 ±2°C (75 ±3°F)	-40 and +120°C[b,c] (-40 and +250°F)	—
Ambient Temperature	24 ±2°C (75 ±3°F)	-40 and +80°C[b] (-40 and +180°F)	-55 and +80°C (-65 and +180°F)
Relative Humidity	50 ±10%	0 and 100%	0 and 100% noncondensing
Supply Voltage 4 to 20 mA dc 10 to 50 mA dc	30 ±0.5 V dc 80 ±0.5 V dc	Refer to Supply Voltage Requirements and External Loop Load Limitations Section	—
Output Load 4 to 20 mA dc 10 to 50 mA dc	650 Ω 600 Ω		

(a) At static pressures above 34 kPa (5 psi) absolute. Refer to Foxboro for static pressures below this value
(b) Limits are −18 and +80°C (0 and 180°F) with Fluorinert-filled sensor at static pressure above 62 kPa (9 psi) absolute. Refer to Foxboro for static pressure below this value.
(c) With pvdf process covers: 66°C at 4 MPa, and 93°C at 2.7 MPa (150°F at 600 psi, and 200°F at 400 psi)

MODEL CODE

823DP = Transmitter

Output Signal
-I = 4 to 20 mA dc
-H = 10 to 50 mA dc

Static Pressure Rating and Process Cover Material
1P = 4 MPa (600 psi, 40 bar or kg/cm2), pvdf (Process Connector Code 7 only)
3K = 20 MPa (3000 psi, 200 bar or kg/cm2), carbon steel (cs)
3S = 20 MPa (3000 psi, 200 bar or kg/cm2), 316 ss
3C = 20 MPa (3000 psi, 200 bar or kg/cm2), Hastelloy C. (With Process Connector Codes 2, 4, and 0 only)
3M = 20 MPa (3000 psi, 200 bar or kg/cm2), Monel
6K = 40 MPa (6000 psi, 400 bar or kg/cm2), cs (Span Limit Codes M and H only)
6S = 40 MPa (6000 psi, 400 bar or kg/cm2), 316 ss (Span Limit Codes M and H only)

Sensor Fill Fluid
1 = Silicone oil
2 = Fluorinert

Sensor Wetted Parts
N = Cobalt-nickel-chrome alloy (standard)
S = 316 ss
C = Hastelloy C-276
M = Monel
T = Tantalum (Static Pressure Codes 1 and 3, and med. and high span limits only)

Span Limits
L = 1.2 and 7.2 kPa (5 and 30 inH_2O, 12 and 72 mbar) ΔP (Static Pressure Code 3 only)
M = 6 and 36 kPa (25 and 150 inH_2O, 60 and 360 mbar) ΔP
H = 30 and 180 kPa (125 and 750 inH_2O, 300 and 1800 mbar) ΔP

Process Connectors
1 = Tapped for 1/4 NPT
2 = Tapped for 1/2 NPT
3 = Tapped for R1/4
4 = Tapped for R1/2
5 = None, process covers machined for 9/16-18 Amincc fitting. (Static Pressure Code 6 only)
6 = Weld neck for 14 x 21 mm tubing (1/2 in Schedule 80 pipe) (Static Pressure Codes 3K, 3S, and 3M only)
7 = None, pvdf covers tapped for 1/2 NPT (for Pressure Rating Code 1P only)
0 = None (Standard process covers are tapped for 1/4 NPT)

Optional Selections
-A = Indicator with 0 to 100% uniform scale
-B = Indicator with 0 to 100% square-root scale
-C = Indicator with scale per sales order
-D = Indicator with 0 to 10 square-root scale
-S = Integrally-mounted square-root extractor (with Output Signal Code -I only, not available with Optional Selections Code -B and -D). This option only ava lable with Electrical Classification Codes CS-E/XB-F, CS-E/XD-F, and CS-E/CG-A.
-Y = Delete mounting bracket

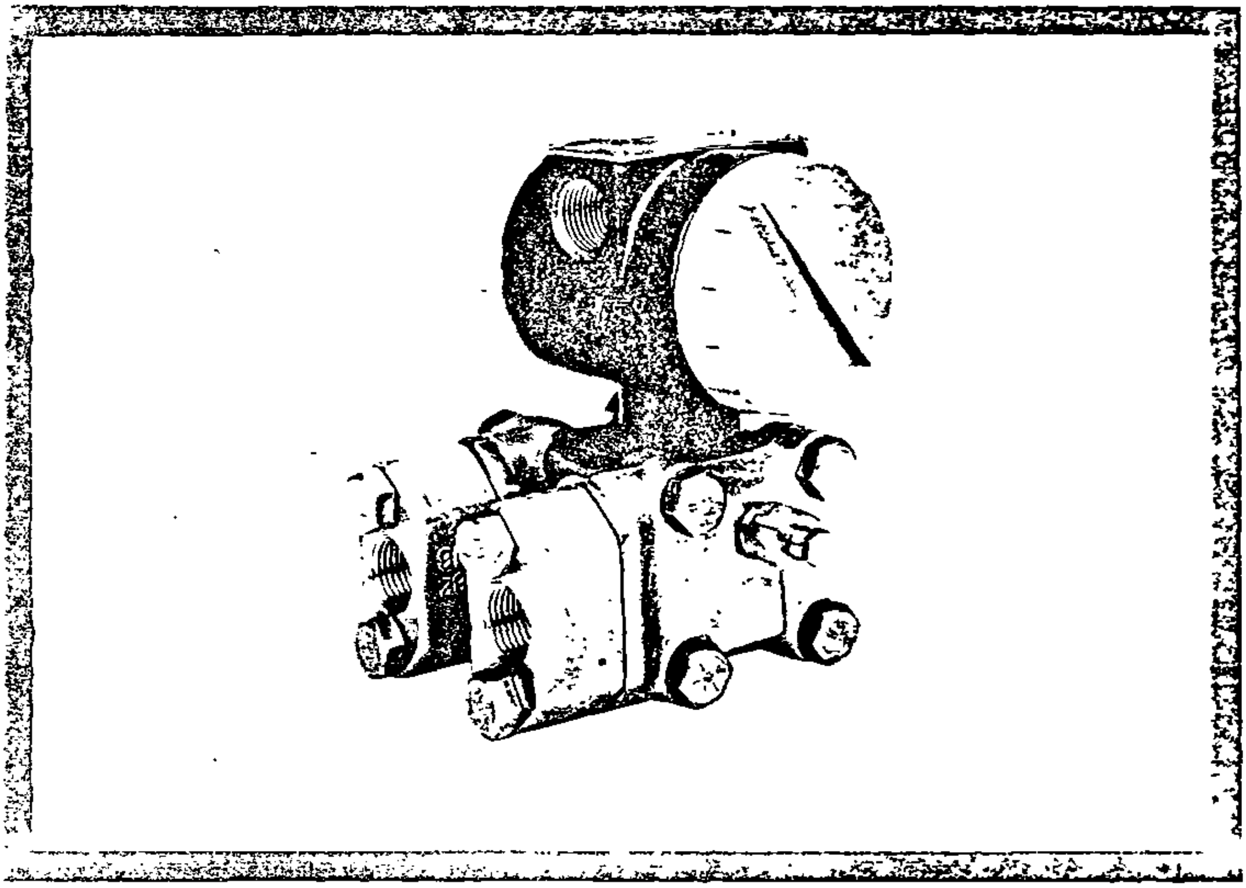
Example: 823DP-I3S1NM2-B

PRODUCT SAFETY SPECIFICATION

Electrical Classification

Testing Laboratory, Types of Protection, and Area Classification	Conditions of Certification	Electrical Classification Code
BASEEFA certified Ex n for IIC, Zone 2.	4 to 20 mA output only. Connect to source not exceeding 45 V. Temperature Class T4 in 80°C ambient, or T6.	CS–E/BN–A
BASEEFA certified intrinsically safe EEx ib for IIC, Zone 1 (CENELEC).	4 to 20 mA output only. Connect to BASEEFA-certified intrinsically safe associated apparatus. Temperature Class T4, T5, or T6	CS–E/PB–E
CSA certified intrinsically safe apparatus for Class I, Groups A, B, C, and D, Division 1; and Class II, Groups E, F, and G, Division 1.	4 to 20 mA output only. Connect per TI 005-105. Temperature Class T6.	CS–E/CB–A
CSA certified intrinsically safe apparatus for Class I, Groups A, B, C, and D, Division 1.	4 to 20 mA output only. Connect to CSA-certified barriers rated 33 V, 415 Ω, 30 V, 300 Ω, 28 V, 240 Ω, 26.7 V, 200 Ω, or 20 V, 70 Ω. Temperature Class T4A	
CSA certified intrinsically safe apparatus for Class I, Groups C and D, Division 1.	4 to 20 mA output only. Connect to CSA-certified barriers rated 33 V, 185 Ω, 30 V, 130 Ω, 28 V, 115 Ω; or 20 V, 30 Ω. Temperature Class T4A.	
CSA certified explosionproof apparatus for Class I, Groups B, C, and D, Division 1; and dust-ignition-proof apparatus for Class II, Groups E, F, and G, Division 1.	4 to 20 or 10 to 50 mA output. Temperature Class T6.	CS–E/CD–A
CSA certified suitable for use in Class I, Groups A, B, C, and D, Division 2 locations.		
CSA certified for use in general purpose (ordinary) locations.	4 to 20 mA output only. Temperature Class T6	CS–E/CG–A(a)
FM certified intrinsically safe apparatus for Class I, Groups A, B, C, and D, Division 1; and Class II, Groups E and G, Division 1.	4 to 20 mA output only. Connect per TI 005-101. Temperature Class T6.	CS–E/FB–A
FM certified intrinsically safe for Class I, Groups C and D, Division 1; and Class II, Groups E and G, Division 1.	4 to 20 mA output only. Connect to Honeywell 38 barrier. Refer to TI 005-101 for barrier types and groups. Temperature Class T6.	CS–E/FB–H
FM certified intrinsically safe for Class I, Groups A, B, C, and D, Division 1; and Class II, Groups E and G, Division 1.		
FM certified explosionproof apparatus for Class I, Groups B, C, and D, Division 1; and dust-ignition-proof apparatus for Class II, Groups E and G, Division 1.	4 to 20 or 10 to 50 mA output. Temperature Class T6	CS–E/FD–A
FM certified nonincendive apparatus for Class I, Groups A, B, C, and D, Division 2; and Class II, Group G, Division 2.		
Foxboro self-certified intrinsically safe apparatus for use in Class I, Groups A, B, C, and D, Division 1; and Class II, Groups E and G, Division 1.	4 to 20 mA output only. Temperature Class T6	CS–E/XB–F(a)
Foxboro self-certified explosionproof apparatus for use in Class I, Groups B, C, and D, Division 1; and dust-ignition-proof apparatus for Class II, Groups E and G, Division 1.	4 to 20 mA output only. Temperature Class T6	CS–E/XD–F(a)
LCIE certified flameproof combined with intrinsic safety EExd [ia] for IIC, Zone 1.	4 to 20 mA output only. Temperature Class T6	CS–E/LD–E
PTB certified intrinsically safe apparatus EEx ib for IIC, Zone 1 (CENELEC). Also accepted for use in all EEC member countries and in some CENELEC member countries outside the EEC. BASEEFA systems certificates have been obtained to permit connection with approved Zener barriers or with other Foxboro associated safe-area apparatus. Refer to Foxboro	4 to 20 mA output only. Connect to PTB-certified intrinsically safe associated apparatus. Temperature Class determined by power (P≤0.56 W, T6; P≤0.75 W, T5; P≤1.20 W, T4	CS–E/PB–E
SAA certified intrinsically safe Ex ib for IIC, Zone 1	4 to 20 mA output only. Connect per drawings [illegible]FL and [illegible]EL. Temperature Class T6	CS–E/AB–A
SAA certified flameproof Ex d for IIB, Zone 1	4 to 20 or 10 to 50 mA output. Temperature Class T6	CS–E/AD–A

(a) Refer to Optional Selection –S in Model Code table.



843 d/p Cell TRANSMITTER

These compact, cost-saving transmitters precisely measure differential pressure and transmit a proportional 4 to 20 mA dc signal.

DIRECT PROCESS MOUNTING

With its small size and light weight, the *843 d/p Cell Transmitter* can be supported by the process piping. This greatly reduces the cost of installation and maintenance as compared to other transmitters which require a pipe stand and mounting bracket.

COMPACT SIZE AND LIGHTWEIGHT

This transmitter utilizes integrated circuit sensor technology to deliver accurate and dependable differential pressure measurements. It is compact in size and weighs only 2.8 kg (6.2 lb).

LOW COST OF OWNERSHIP

Not only is the initial cost of this transmitter attractive, but cost considerations must also include the savings realized as a result of the unit's total replacement concept. The lightweight, compact, and direct process mounted design promotes ease of initial installation or rapid replacement of the transmitter. In addition, spare-parts inventory and maintenance training is totally eliminated. Combine these features with the corrosion, overrange, and radio-frequency interference (RFI) protection and the result is a transmitter with the lowest cost of ownership in the market today.

FOXBORO®

CORROSION PROTECTED

The 843 d/p Cell Transmitter may be used for differential pressure measurement of corrosive liquids or vapors. All sensor wetted parts are a cobalt-nickel alloy. Sensor covers and process connectors are 316 ss. In addition, the transmitter housing is coated with a durable and chip-resistant epoxy finish for superior protection in corrosive atmospheres.

MOISTURE PROTECTION

The electronics compartment of the transmitter is potted and O-ring sealed for dual protection against moisture.

OVERRANGE PROTECTION

The 834 d/p Cell Transmitter will withstand overranges up to a static pressure of 2000 psi (14 MPa) with negligible change in output.

RADIO-FREQUENCY INTERFERENCE (RFI) PROTECTION

The transmitter is protected against RFI by two sealed filters between the electronic compartment and the field terminal compartment of the housing.

FUNCTIONAL SPECIFICATIONS

Operating Conditions

Influence	Reference Operating Conditions	Operative Limits	Transportation and Storage Limits
Process Temperature	24 ± 2°C (75 ± 3°F)	−45 and + 120°C (−50 and + 250°F)	Not Applicable
Ambient Temperature	24 ± 2°C (75 ± 3°F)	−45 and + 80°C (−50 and + 180°F)	−55 and + 80°C (−65 and + 180°F)
Relative Humidity	50 ± 10%	0 to 100%	0 to 100% noncondensing
Supply Voltage[a]	30 ± 0.5 Vdc	12.5 to 36 Vdc	Not Applicable
Output Load[a]	650 Ω	0 to 1175 Ω	Not Applicable

[a]Refer to figure on Page 3

Span, Range, and Overrange Limits

Span Limit Code	Span Limits (Differential Pressure [ΔP])			Upper Range Limit (ΔP)			Overrange Limit (ΔP) and Maximum Static Pressure		
	kPa	inH_2O	mbar	kPa	inH_2O	mbar	MPa	psi	kg cm2
H	19 and 75	75 and 300	190 and 750	75	300	750	14	2000	140
	MPa	psi	bar or kg/cm2	MPa	psi	bar or kg/cm2	MPa	psi	bar or kg/cm2
A	0.05 and 0.20	7.5 and 30	0.5 and 2.0	0.20	30	2.0	14	[illegible]	14
B	0.17 and 0.7	25 and 100	1.7 and 7	0.7	100	7	14	2000	140
C	0.5 and 2.0	75 and 300	5 and 20	2.0	300	20	14	2000	14
D	1.7 and 7.0	250 and 1000	17 and 70	7.0	1000	70	14	2000	14
E	5.0 and 14	750 and 2000	50 and 140	14	2000	140	14	2000	140

Output Signal 4 to 20 mA dc

Calibration Adjustments

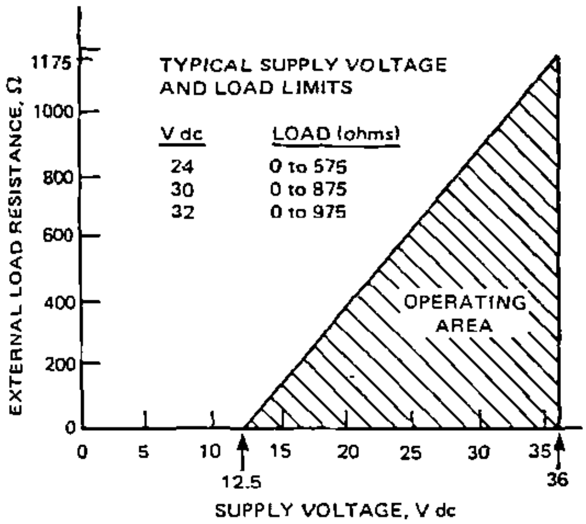
Zero Adjustment
843DP — internal
843DX — external

Span Adjustments
843DP and 843DX — internal

Zero Suppression 100% of calibrated span

Housing The transmitter housing is comprised of two separate compartments. One contains the transmitter electronics and the other contains the field terminal connections. Each compartment is accessible by removal of a threaded cover. Field wires enter through 1/2 NPT conduit on either side of the housing. Wires terminate under screw terminals and washers in the field terminal compartment.

Supply Voltage Requirements and External Loop Load Limitations



Model Code

843 = d/p Cell Transmitter

Electronic Housing Configuration
- DP = Standard
- DX = Explosionproof with External Zero Adjustment

Span and Range Limits
- -H = 19 and 75 kPa or 75 and 300 inH_2O
- -A = 0.05 and 0.20 MPa, 7.5 and 30 psi, or 0.5 and 2.0 bar or kg/cm2
- -B = 0.17 and 0.7 MPa, 25 and 100 psi, or 1.7 and 7 bar or kg/cm2
- -C = 0.5 and 2.0 MPa, 75 and 300 psi, or 5 and 20 bar or kg/cm2
- -D = 1.7 and 7.0 MPa, 250 and 1000 psi, or 17 and 70 bar or kg/cm2
- -E = 5.0 and 14 MPa, 750 and 2000 psi, or 50 and 140 bar or kg/cm2

Process Connectors
- 0 = Without (Covers tapped 1/4 NPT)
- 1 = 1/4 NPT
- 2 = 1/2 NPT
- 3 = RC 1/4
- 4 = RC 1/2
- 6 = 1/2 Schedule 80 Welding Neck

Optional Selection
- -M = Mounting Set

Example: 843DP-B2-M

PERFORMANCE SPECIFICATIONS

(Under reference operating conditions unless otherwise specified)

Accuracy (Includes linearity, hysteresis, and repeatability) ±0.25% of span

Drift[1] (Over a 6-month period). Less than ±0.3% of maximum span

Static Pressure Effect[1] Zero shift and total effect (maximum effect at any point on scale) does not exceed 1.0% of span, per 6.7 MPa (1000 psi) change in static pressure at maximum span.

Ambient Temperature Effect[1] The total effect (maximum effect at any point on scale) as a percent of maximum span per 28°C (50°F) change, is as follows:

From -29 to -1°C (-20 to +30°F)	From -1 to +54°C (30 to 130°F)	From 54 to 80°C (130 to 180°F)
±1.2%	±0.75%	±1.0%

Overrange Effect[1] Zero shift does not exceed 0.2% of span when applying an overrange pressure of 2000 psi.

RFI Effect The output error is less than 0.1% of span for radio frequencies between 27 and 500 MHz and field intensity of 10 V/m when the transmitter is properly installed and the housing covers are in place.

Supply Voltage Effect The output changes less than 0.005% of span for each 1 V change within the specified supply voltage requirements. See "Supply Voltage Requirements and External Loop Load Limitations".

Position Effect The output changes less than 0.05% of span for a 90° tilt in any direction.

Vibration Effect The total effect (maximum effect at any point on scale) at frequencies up to 200 Hz and amplitudes up to 6 mm (0.25 in) peak-to-peak, or for accelerations up to 10 m/s2 (1 "g") whichever is smaller, is less than 0.1% of span

[1]For each Span Limit Code

PHYSICAL SPECIFICATIONS

Process-Wetted Parts Materials
- **Sensor** Cobalt-Nickel-Chromium alloy
- **Process Covers/Connectors/Vent Screw** 316 ss

Non Process-Wetted Parts Materials
- **Sensor Housing** AISI Type 430 ss
- **Electronic Housing and Covers** Low copper die-cast aluminum alloy with epoxy finish. The covers are threaded and seat on Buna-N O-rings.

Fill Fluid Dimethylsiloxane (DC-200)

Environmental Protection The transmitter housing is weatherproof and dusttight as defined in IEC IP65 and provides the watertight protection of NEMA Type 4.

Approximate Mass (843DP) 2.8 kg (6.2 lb). with process connectors, add 0.7 kg (1.5 lb)

PRODUCT SAFETY SPECIFICATIONS

Electrical Classification

Testing Laboratory, Types of Protection, and Area Classification	Conditions of Certification	Electrical Classification Code
FM certified intrinsically safe for Class I, Groups A, B, C, and D, Division 1; and Class II, Groups E and G, Division 1.	843 DP only. Connect to Foxboro or other manufacturer's associated apparatus that is FM certified under the entity concept and operating within the maximum entity parameters per TI 005-101. Temperature Class T6	CS–E/FB–A
FM certified nonincendive for Class I, Groups A, B, C, and D; Division 2: and Class II, Group G, Division 2.	843DP only. Temperature Class T6.	CS–E/FN–A
Foxboro certified explosion-proof for Class I, Groups B, C, and D, Division 1 and dust-ignition-proof for Class II, Groups E and G, Division 1.	843DX only. Temperature Class T6.	CS–E/XD–F
Foxboro certified nonincendive for Class I, Groups A, B, C, and D, Division 2 and Class II, Group G, Division 2.		

WARRANTY

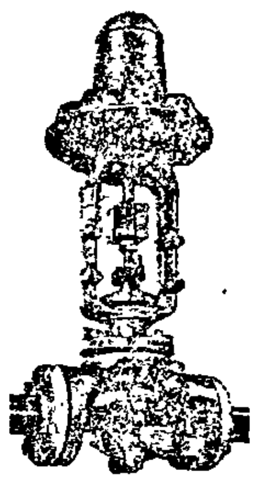
Foxboro warrants the original purchaser that Foxboro manufactured 843 d/p Cell Transmitters shall be free from defects in material and workmanship, and agrees to either replace or repair free of charge, any such transmitter or part thereof which shall be returned to the nearest authorized Foxboro repair facility within one year (or five years with Optional Feature EW) from date of delivery, transportation charges prepaid by the purchaser. Purchaser retains responsibility for the application, corrosion resistance, and functional adequacy of the transmitter. For further details of this warranty, refer to Section 11A of "General Conditions of Sale for Instruments and Parts" available from Foxboro.

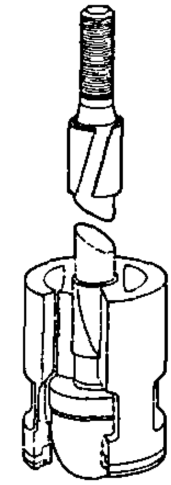
FOXBORO

V1 SERIES STABIFLO CONTROL VALVES
1 1/2 to 6-Inch Sizes, Stem Guided Plug

General Specification

For fine proportioning control of a wide variety of fluids. Provides wide rangeability, tight shutoff and Cv values up to 400. Designed for maximum inherent resistance to corrosive or dirty fluids.





Fine Proportioning Control with a choice of linear or equal percentage control characteristics, wide rangeability and long stroke, fast response actuators.

Long Lasting Inner Valve Construction has hardened M-A stainless steel plug and seat ring. A true stainless steel, it withstands corrosion as well as extremely high pressure drops. Optional trim materials for extremely corrosive fluids are also available.

M-A (Martensitic Aging) Stainless Steel is a precipitation hardened alloy steel with 15 to 17% chrome and 3.5 to 5.5% nickel content. It is highly resistant to both erosion and corrosion.

Stem Guided for maximum guide surface life in corrosive or dirty fluids. Two, low friction, large area guides result in minimum hysteresis and high pressure operation.

Full Ported Inner Valve Design with exceptionally high flow capacity reduces initial cost by allowing the use of smaller body sizes than would be required with previous globe valve designs.

Optional Reduced Port Inner Valve Design with 40% of full capacity allows proper valve sizing for present conditions and permits simple change to full ported inner valve for future increased flow. Saves on total valving costs and eliminates costly piping changes to install larger valve in the future. Also used to reduce exit velocity in high flow, high pressure applications.

Flexible Design provides for field conversion from one inner valve type to another (i.e., stem guided to cage guided, equal percentage to linear) for that particular body size.

PERFORMANCE DATA

Rangeability Better than 50:1
Leakage Cv Maximum Cv ÷ 10,000
Maximum Throttling Differential Pressure Equal to working pressure rating
Maximum Differential Shutoff Pressure 1300 psi (91 kg/cm2). See Table 1.
Stem Friction (Hysteresis)
1 1/2 to 3-inch sizes — less than 25 lb
4 and 6-inch sizes — less than 40 lb

Simplified Maintenance with easily replaced cage retained trim, fully gasketed internal surfaces and fewer wearing parts.

Prolonged Packing Life results from the use of an upper stem guide bushing above the packing to prevent stem flexing or lateral movement which would cause packing distortion. Wiper and bushing isolate packing from foreign particles.

STANDARD SPECIFICATIONS

Sizes 1 1/2, 2, 3, 4 and 6 inches

Body Materials Cast steel (ASTM A216 WCB), 316 stainless steel (ASTM A351 Grade CF8M) or cast iron (ASTM A126 Class B)

End Connections

Body Material	Threaded	125 FF, 250 RF	150 RF	300 RF	600 RF
Cast Steel	1 1/2 + 2" (a)	–	All Sizes	All Sizes	All Sizes
316 SS	–	–	All Sizes	All Sizes	All Sizes
Cast Iron	1 1/2 + 2" (b)	All Sizes	–	–	–

(a) 1440 psig (101 kg/cm2) at 100 F (38 C).
(b) 400 psig (28 kg/cm2) at 100 F (38 C).

Bonnet Bolted type with bolted adjustable packing box. Bonnet material same as body material.

Studs, Nuts and Bolts Studs A193 Grade B7 alloy steel. Nuts A194 Grade 2H steel. Bolts (cast iron valves) A307-65 Grade B steel.

Packing Box Flange carbon steel
- **Follower** 300 Series stainless steel
- **Studs** 300 Series stainless steel
- **Nuts** 400 Series stainless steel
- **Top Wiper** 316 stainless steel with felt ring
- **Bottom Wiper** Reinforced TFE
- **Top Bushing** Reinforced TFE

Packing Spring loaded, molded TFE V-ring

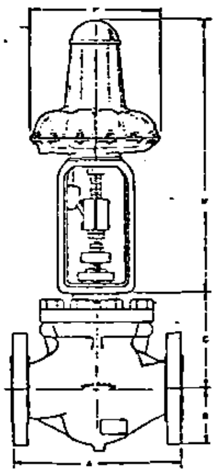
TABLE 1

Body Size (Inches)	Trim Size	Cv Value	Supply Pressure (psi)	Actuator and Shutoff Pressure Range				
				P25d	P50d	P50f	P110d	P110f
1/2, 3/4, 1	1/4	1.0	20 35	0- 675 0- 900	0-1350 0-2250	900-2500 1800 2500	0-2500 0-2500	– –
	3/8	2.0	20 35	0- 675 0- 900	0-1350 0-2250	900-2500 1800-2500	0-2500 0-2500	– –
	1/2	5.0	20 35	0- 225 0- 375	0- 475 0- 800	300-1125 500-1950	0-1125 0-1950	650-2500 1000-2500
3/4, 1	3/4	10.0	20 35	0- 120 0- 160	0- 240 0- 400	150- 580 300- 980	0- 580 0- 980	350-1250 600-2500
1	1	17.0	20 35	0- 70 0- 100	0- 150 0- 250	125- 350 250- 650	0- 350 0- 600	200- 760 400-1525

Body Material	End Connections	Pressure (psi) vs Temperature Ratings				
		100 F (38 C)	406 F (208 C)	500 F (260 C)	850 F (454 C)	1125 F (607 C)
Cast Steel	Threaded + Socket Weld	2500	–	2170	1045	–
	150	275	–	150	–	–
	300	720	–	625	300	–
	600 + 600 RTJ	1440	–	1110	600	–
316 SS	Threaded, Socket Weld + 600	2500	–	2170	1475	1045
	150	275	–	150	–	–
	300	720	–	625	425	300
Cast Iron	Threaded	400	250	–	–	–
	125	175	125	–	–	–
	250	400	250	–	–	–

DIMENSIONS

FIGURES EXPRESSED IN INCHES AND MILLIMETERS



Actuator	P25		P50		P110	
	in.	mm	in.	mm	in.	mm
M	16 15/16	430	20 3/4	527	29 7/16	748
P	7 7/8	200	10 1/2	267	15 1/8	384

Actuator	P25		P50		P110	
Approximate Weight*	lb	kg	lb	kg	lb	kg
	17	8	32	15	66	30

*Includes yoke and mounting parts

Valve Size (Inches)	A											
	Threaded		125		150		250		300		600, 600 RTJ	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
1/2	6 7/8	175	–	–	7 1/4	184	–	–	7 1/2	191	8	203
3/4	6 7/8	175	–	–	7 1/4	184	–	–	7 5/8	194	8 1/8	206
1	7 1/4	184	7 1/4	184	7 1/4	184	7 3/4	197	7 3/4	197	8 1/4	210

Valve Size (Inches)	B								C		Approximate Weight			
	Threaded		125		150		250, 300, 600, 600 RTJ				Threaded		Flanged	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb	kg	lb	kg
1/2	2 1/8	54	–	–	2 5/8	67	2 5/8	67	4 1/4	108	14	6	21	10
3/4	2 1/8	54	–	–	2 5/8	67	2 5/8	67	4 1/4	108	14	6	21	10
1	2 7/16	62	2 3/8	60	2 7/16	62	2 1/2	64	4 5/8	117	19	9	28	13

STANDARD SPECIFICATIONS
(Continued)

Inner Valve Stem guided, single seat, cage retained seat ring. Contoured equal percentage or linear characteristic.

Sizes and Cv Values See Table 1

Rangeability Better than 50:1 (minimum controllable Cv less than 1/50 of maximum).

Travel See Table 1

Plug and Seat Ring M-A stainless steel hardened to 302 Brinnell (32 Rockwell C).

Stem 316 stainless steel

Cage Carbon steel for steel or iron body, 316 stainless steel for 316 stainless steel body.

Gaskets Asbestos for body, cage and bonnet; spiral wound 316 stainless steel/asbestos for seat ring.

Guide Bushing Reinforced TFE

Diaphragm Actuator Reversible P50 or P110, die-cast aluminum topworks with iron yoke. Air connection 1/4 NPT. Signal range 3 to 15 or 6 to 30 psi (0.2 to 1.0 or 0.4 to 2.1 kg/cm2) nominal standards. Maximum supply pressure 60 psig (4.2 kg/cm2).

Valve Action Air-to-open (fail closed) or air-to-close (fail open), as specified.

Temperature Limits 0 to 450 F (-18 to +232 C) for cast steel and 316 stainless steel bodies; 30 to 406 F (-1 to +208 C) for cast iron bodies.

OPTIONAL EXTRA FEATURES

End Connections

Ring Type Joint Flanges 600 lb ANSI RTJ for 1 1/2 through 6 inch, cast steel bodies only.

Socket Weld Ends 1440 psig (101 kg/cm2) at 100 F (38 C). For 1 1/2 and 2-inch, cast steel bodies only.

Finned Insulating Extension Bonnet for steel or 316 stainless steel bodies. Extends the temperature limits to the high and low limits of the valve body material. Finned housing is same material as body. Insulation is 316 stainless steel mesh in stainless steel retainer. Hardened 440C stainless steel guide bushing.

Packing TFE impregnated asbestos or graphite impregnated asbestos with lubricator and silicone lubricant. Fluorolube lubricant also available. Steel valves supplied with steel isolating valve. 316 stainless steel valves supplied with 316 stainless steel isolating valve.

Inner Valve 316 stainless steel cage in iron or steel bodies. Alloy 20, nickel, Monel or Hastelloy C alloy plug, seat ring and stem.

Handwheel Jackscrew for emergency manual operation or startup. Top mounted version available for P50 or P110 actuator. Design allows for field reversing of actuator action.

Type C Vernier Valvactor Positioner with or without bypass and gauge manifold. Offsets hysteresis and provides fast, precise valve position in response to a 3 to 15 psi (0.2 to 1.0 kg/cm2) control signal. See GS 4-10A1 A.

Model 69TA-1 Current-to-Air Transducer converts a d-c milliampere input signal to a proportional pneumatic output signal for instruments, valve actuators and other pneumatic devices. See GS 4-8C1 A.

Model 69PA-1 Current-to-Air Positioner combines the functions of a current-to-air transducer and a pneumatic positioner in one instrument to offset hysteresis and provide fast, precise valve position in response to a d-c milliampere control signal. See GS 4-10B1 A.

Type CP Pneumatic Position Transmitter provides a 3 to 15 psi (0.2 to 1.0 kg/cm2) pneumatic signal proportional to valve position for remote indication or recording of valve performance. See GS 2B-1B1 B.

Electric Signal Limit Switches in various yoke mounted versions are available for remote position indication.

Air Sets consisting of filter regulators with or without 2-inch, 0-30 psi gauge are rigidly attached to actuator housing and preconnected to pneumatic accessories when specified.

TABLE 1

Body Size (Inches)	Travel	Trim Size	Cv Value	Supply Pressure (psi)	Actuator and Shutoff Pressure Range							
					P50f	P50g	P50j	P110f	P110g	P110j	P110k	P110m
1 1/2	1	1 1/2	34.0	20	0- 50	35-100	50-125	0-110	75- 235	110- 275	–	–
				35	0- 90	60-180	100-235	0-200	150- 400	200- 550	–	–
		40%	15.0	20	0-125	100-250	125-300	0-275	200- 550	250- 650	–	–
				35	0-225	175-450	250-580	0-500	300-1000	500-1300	–	–
2	1 1/4	2	60.0	20	–	0- 35	20- 60	–	0- 110	50- 165	75- 220	–
				35	–	0- 60	40-110	–	0- 165	90- 275	150- 415	–
		40%	24.0	20	–	0-100	55-160	–	0- 300	125- 450	200- 590	–
				35	–	0-160	100-300	–	0- 450	250- 740	400-1100	–
3	1 1/2	3	120	20	–	–	0- 18	–	–	0- 55	30- 95	40-105
				35	–	–	0- 30	–	–	0- 80	50- 160	70-185
		40%	48.0	20	–	–	0- 45	–	–	0- 145	70- 250	85-285
				35	–	–	0- 75	–	–	0- 215	125- 425	200-495
4	2	4	200	20	–	–	–	–	–	–	0- 30	15- 38
				35	–	–	–	–	–	–	0- 45	25- 72
		40%	80	20	–	–	–	–	–	–	0- 80	30-100
				35	–	–	–	–	–	–	0- 120	60-180
6	2 1/4	6	400	20	–	–	–	–	–	–	–	0- 13
				35	–	–	–	–	–	–	–	0- 24
		40%	160	20	–	–	–	–	–	–	–	0- 32
				35	–	–	–	–	–	–	–	0- 59

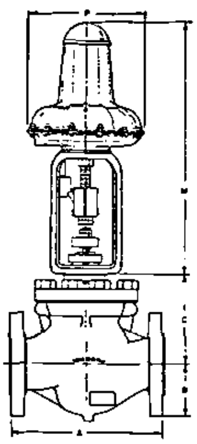
ORDERING INSTRUCTIONS – SPECIFY

1. Foxboro V1 Series Stabilflo Control Valve, Stem Guided Trim
2. Size
3. Body Material and End Connections
4. Inner Valve: Size and Characteristic
5. Required Differential Shutoff Pressure
6. Actuator Size, Supply Pressure and Signal Range
7. Air-to-Open or Air-to-Close Action
8. Operating Conditions
9. Optional Extra Features
10. Tag and Application

Body Material	End Connections	Pressure (psi) vs Temperature Ratings				
		100 F (38 C)	406 F (208 C)	500 F (260 C)	850 F (454 C)	1125 F (607 C)
Cast Steel	Threaded, Socket Weld, 600, 600 RTJ	1440	–	1110	600	–
	150	275	–	150	–	–
	300	720	–	625	300	–
316 SS	Threaded, Socket Weld & 600	1440	–	1110	850	600
	150	275	–	150	–	–
	300	720	–	625	425	300
Cast Iron	Threaded	400	250	–	–	–
	125	175	125	–	–	–
	250	400	250	–	–	–

DIMENSIONS

FIGURES EXPRESSED IN INCHES AND MILLIMETERS



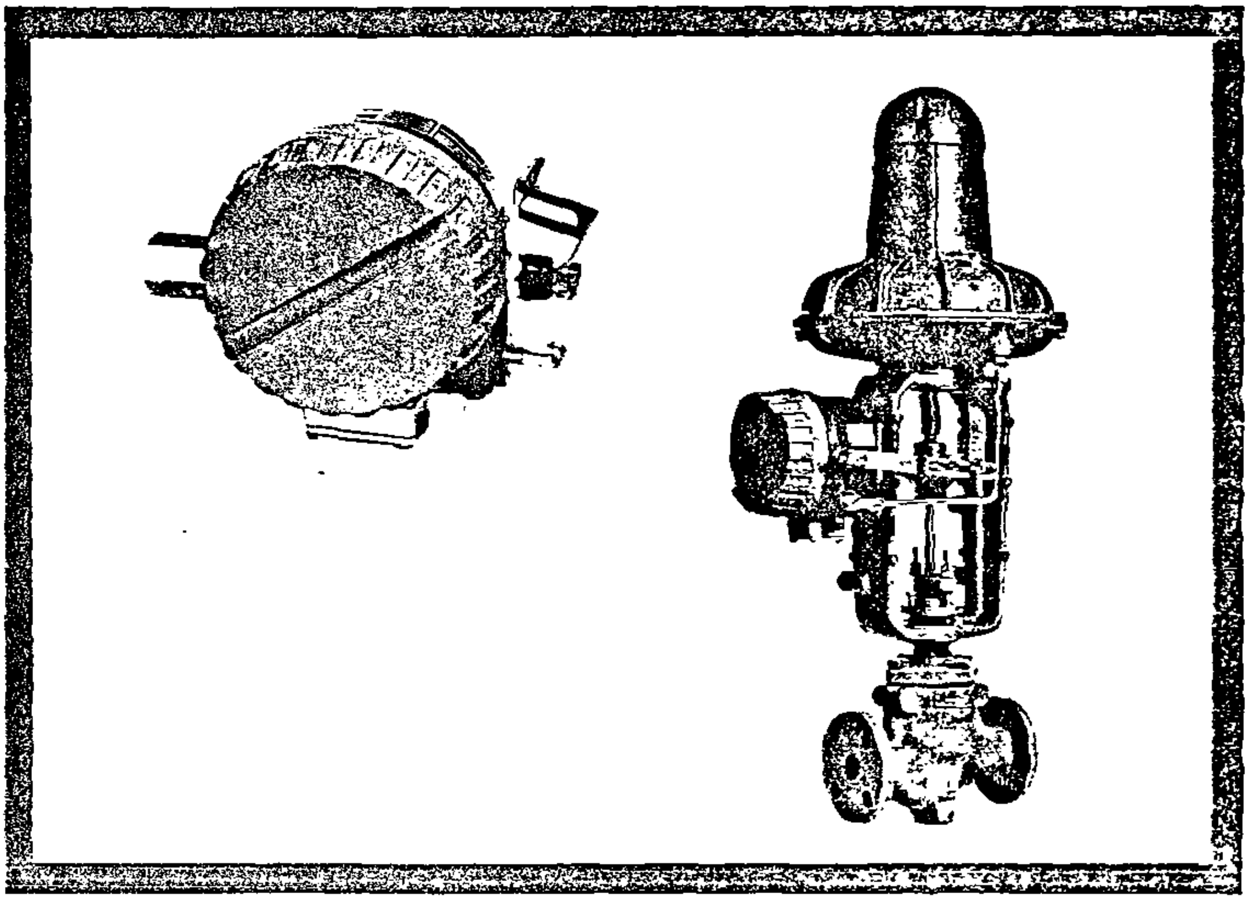
Actuator	P50		P110	
	in.	mm	in.	mm
M	20 3/4	527	29 7/16	748
P	10 1/2	267	15 1/8	384

Actuator	P50		P110	
Approximate Weight*	lb	kg	lb	kg
	32	15	66	30

*Includes yoke and mounting parts.

Valve Size (Inches)	A										Approximate Weight			
	Threaded		125, 150		250, 300		600		600 RTJ		Threaded		Flanged	
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	lb	kg	lb	kg
1 1/2	8 3/4	222	8 3/4	222	9 1/4	235	9 7/8	251	9 7/8	251	49	22	62	28
2	11 3/8	289	10	254	10 1/2	267	11 1/4	286	11 3/8	289	68	31	82	37
3	–	–	11 3/4	298	12 1/2	318	13 1/4	337	13 3/8	340	–	–	137	62
4	–	–	13 7/8	352	14 1/2	368	15 1/2	394	15 5/8	397	–	–	216	98
6	–	–	17 3/4	451	18 5/8	473	20	508	20 1/8	511	–	–	392	178

Valve Size (Inches)	B												C	
	Threaded		125		150		250		300		600 600 RTJ			
	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
1 1/2	3 5/16	84	3 5/16	84	3 5/16	84	3 5/16	84	3 5/16	84	3 5/16	84	6	152
2	3 3/8	86	3 7/8	98	3 3/4	95	3 13/16	97	3 13/16	97	3 13/16	97	6 7/8	175
3	–	–	4 9/16	116	4 1/2	114	4 9/16	116	4 1/2	114	4 1/2	114	7 1/4	184
4	–	–	5 1/4	133	5 3/8	137	5 1/4	133	5 3/8	137	5 7/16	138	8 1/2	216
6	–	–	7	178	6 15/16	176	6 15/16	176	6 15/16	176	7 1/16	179	10 1/4	260



E69P CURRENT-TO-PNEUMATIC VALVE POSITIONER

The E69P Positioner, mounted directly on a pneumatic valve yoke, converts a standard direct current input signal to a proportional valve stem position.

COMPACT, EASILY MOUNTED ON VALVE YOKE

Because of its small size, compact design, and simple connection mechanism, the E69P Positioner can be quickly and conveniently mounted on a wide variety of valve or other types of pneumatic actuators.

VIBRATION AND INCLINATION EFFECTS MINIMIZED

Pipe line vibration normally encountered has minimal effect upon the E69P. Also, the effects of inclination are minimal, allowing the valve to be mounted without regard for the attitude of the positioner. Low mass components, along with a statically balanced and well-supported coil in the galvanometric motor of the E69P, make these important benefits possible.

MULTIPLE APPLICATIONS

With choice of input, choice of direct or reverse action, split input ranges, and availablity of standard or explosionproof covers, this positioner can be easily adapted for a wide range of applications.

MINIMAL EFFECTS FROM AMBIENT ATMOSPHERIC CONDITIONS

The design of the unique galvanometric motor in the E69P provides for generous clearances between coil and housing. Normal atmospheric changes, which may cause corrosion and dust particles, do not hinder operation of the mechanism, as sometimes happens with voice coil type instruments.

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PERFORMANCE SPECIFICATIONS

(All values are for normal input ranges)

Linearity .... ±1% of span

Repeatability 0.1%

Dead Band 0.1% input, relative to output pressure response.

Open Loop Gain .... Nominally 80

Supply Pressure Effect A change in supply pressure causes a zero shift of less than 0.04% of span per kPa (0.25% per psi) at 50% of span.

Inclination Effect Maximum zero shift is 0.25% of span for a 5 degree angular change in inclination from the vertical. This error can be eliminated by calibrating instrument at its intended mounting position.

FUNCTIONAL SPECIFICATIONS

Model Code

E69P = Current-to-Pneumatic Valve Positioner

Enclosure
- -B = Bolted cover (For use in all non-explosionproof applications)
- -T = Threaded cover (Must be used in all explosionproof applications)[a]

Input Signal Range[b]
- I = 4 to 20, 4 to 12, or 12 to 20 mA dc, direct or reverse action
- H = 10 to 50, 10 to 30 or 30 to 50 mA dc, direct or reverse action

Output Signal[b]
- 1 = 140 or 240 kPa; 20 or 35 psi; 1.4 or 2.4 bar or kg/cm^2
- 9 = 415 kPa; 60 psi 4.1 bar or kg/cm^2

Lever Assembly Mounting Parts
- S to N = Refer to table below

Code	For Use with Valves and Actuators Listed Below	
	Foxboro Valve Series	Actuator Series
S	V1	P25, P50
T	V1	P110
U	V9000, V9300	P50, P110
Q	Other than V1, V9000	P25, P50
R	Other than V1, V9000, V9300	P110
V	Non-Foxboro Valves	P25, P50, P110, and other diaphragm actuators
N	Lever parts and brackets for NAMUR approved actuators	

Optional Selections (Also refer to "Optional Features" section)
- -J = Integral explosionproof junction box
- -M = Miniature junction box with hole tapped for 1/2 inch conduit connection; front entry
- -P = Miniature junction box with hole tapped for 1/2 inch conduit connection; rear entry
- -R = Adjustable filter regulator without gauge
- -S = Supply/output gauges (select per output range requirements)

Example: E69P–BI1S–R (4 to 20 mA dc input, direct action, 35 psi output)

[a] Refer to "Product Safety Specifications" table.
[b] Specify input signal range, and whether direct or reverse action; also specify output signal.

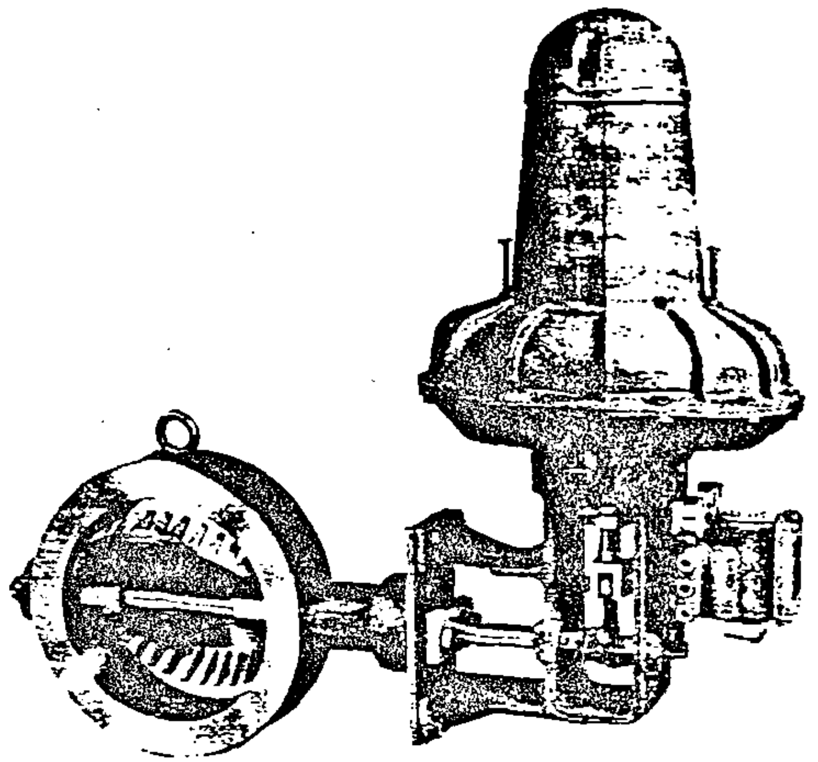
Input Signal Ranges

Normal Range (mA)	Split Ranges	Input Resistance (Ω)
4 to 20	4 to 12 or 12 to 20 mA	170
10 to 50	10 to 30 or 30 to 50 mA	27

Nominal Output Signal* Valve stem positioning achieved within following outputs for an angular feedback lever excursion of 5° minimum and 30° maximum:

kPa	psi	bar or kg/cm^2
140 or 240	20 or 35	1.4 or 2.4
415	60	4.1

* Supply pressure must be at least 20 kPa, 3 psi, or 0.2 bar greater than output signal.



V3000 SERIES BUTTERFLY CONTROL VALVES

INTRODUCTION

The V3000 Series Butterfly Control Valves provide precise control of most common liquids, gases, and steam. Several unique features make this valve a significant departure from the automated butterfly valves commonly used today. This advanced design provides features and benefits as listed in the table below.

This TI provides a brief description of these unique butterfly valves. Also included, is a discussion and numerical data relating to valve capacity, dynamic torque, leakage rate, rated and installed flow characteristics, cavitation resistance, and audible noise level. Refer to PSS 4-6A2 B for the V3000 Series Valve specifications.

Features	Benefits of the V3000 Series Control Valves
Angle Seating	Exceptionally low leakage in a throttling butterfly control valve.
High Rangeability	Suitable for a wide range of applications.
High Quality Design	Provides durable and dependable long-lasting service.
Heavy Duty Valve	Suitable for higher pressure drops than conventional butterfly valves.
Unique Vane Design	Cast-in teeth provide lower torque, resulting in stable operation with smaller actuators. The vane design also provides lower noise and better cavitation resistance.
Ease of Installation	Compact, lightweight design fits between a wide variety of ANSI and DIN flanges; provides for installation savings.

GENERAL DESCRIPTION

These valves have a wafer-body design and are manufactured from either carbon steel or stainless steel. This design provides for easy mounting between ANSI or DIN raised face flanges. The valve is available in nominal 2, 3, 4, 6, 8, 10, 12, and 16 inch sizes. The 2, 3, 4, 6, and 8 inch valves can be installed between ANSI Class 150 or 300, or DIN PN 10, 16 or 25 flanges. The 10, 12, and 16 inch valves are used with ANSI Class 150 or DIN PN 10 or 16 flanges. A Foxboro Model P50 Actuator is used with the 2 to 8 inch valves. A Model P110 Actuator is required for the 10, 12, and 16 inch valves. The actuator is assembled to the valve by means of a rotary drive mechanism. This rotary drive and the actuators are common to many Foxboro valve assemblies.

The valve can operate at temperatures up to 325°F with a stainless steel body. A carbon steel valve can operate at temperatures up to 400°F. Special packings and hardened bearings are optionally provided for temperatures to 750°F for the 316 ss body, and to 650°F for the carbon steel body.

VALVE CAPACITY—C_V

One accepted method of valve sizing is the C_V approach. C_V is a capacity rating coefficient. It is defined as the number of U.S. gpm of 60°F water which will flow through a valve at a specified opening with a pressure drop of 1 psi across the valve.

Economics and control are the two principal reasons for sizing control valves.

Economics If a valve is too small, it will not pass the required flow and will have to be discarded and replaced by a larger, properly sized valve. Similarly, if the valve is too large, it will obviously pass the required flow, but it will be more expensive than a properly sized smaller valve.

Control An undersized valve will never deliver the full flow rate, thus it will sharply narrow the controllable flow range. An oversized valve will be throttling near the closed position, and the full control range of the valve will not be utilized. When the vane throttles very close to the seat, high fluid velocities occur, which can cause erosive damage.

A V3000 Series Valve should normally be selected so that it will operate in the range of 30 to 60 degrees vane opening.

Table 1 lists the C_V values at various valve openings. The valve opening is in terms of vane rotation up to a maximum angle of 70 degrees. Table 1 also lists C_V values when the pipe size is approximately 1.5 times the valve size. These particular C_V values are identified as $C_V F_P$.

DYNAMIC TORQUE

The V3000 Series Valve vane design effectively reduces dynamic torque to a fraction of that of other valves, providing stability and fast speed of response with smaller, less expensive actuators. Figure 1 plots valve vane position versus torque. The curves compare a V3000 Series 4 inch valve with both a competitive low torque vane valve and a conventional butterfly valve. The curves show that the V3000 Series Valves exhibit lower torque values at all vane positions.

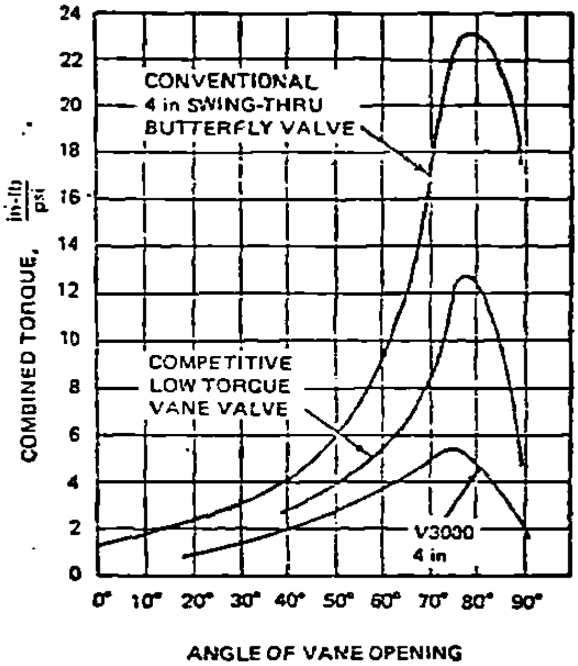
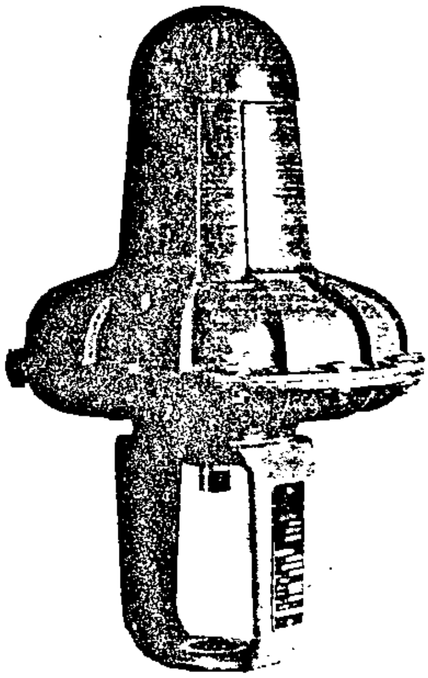


Figure 1. Dynamic Torque

Table 1. C_V and $C_V F_P$ Values—V3000 Series Valves

Valve Size	C_V and $C_V F_P$	Vane Angle in Degrees						
		10°	20°	30°	40°	50°	60°	70° (*)
2 in	C_V	3	11	22	38	53	69	85
	$C_V F_P$	3	11	22	37	50	63	74
3 in	C_V	14	33	58	88	120	140	176
	$C_V F_P$	14	33	58	86	115	133	158
4 in	C_V	17	43	80	127	179	250	363
	$C_V F_P$	17	43	80	126	175	238	323
6 in	C_V	55	120	210	320	450	590	825
	$C_V F_P$	55	120	208	315	441	560	730
8 in	C_V	70	175	350	620	1025	1265	1595
	$C_V F_P$	70	174	345	608	975	1151	1388
10 in	C_V	96	245	455	718	1135	1470	2515
	$C_V F_P$	96	244	450	710	1015	1396	2188
12 in	C_V	160	410	760	1200	1730	2460	3610
	$C_V F_P$	160	405	750	1175	1644	2238	3130
16 in	C_V	210	550	1022	1614	2327	3310	5650
	$C_V F_P$	210	546	1015	1595	2260	3145	5090

(*) Maximum vane angle corresponds to 100% valve opening, with corresponding rated C_V values.



P25, 30, 50, 60, and 110 DIAPHRAGM VALVE ACTUATORS

(With Spring Selection)

INTRODUCTION

The primary function of the P Series Valve Actuators is to position the valve plug in response to the controller output signal. Positioning of the plug is linear because the effective area of the diaphragms and the spring rates of the springs are constant. In addition, the actuator must be capable of closing the valve against line pressure. An air-to-open actuator accomplishes this by initial compressive force on the spring. Air-to-close actuators use controller output signal to shut the valve off against line pressure.

The actuator sizing and spring selection is dependen upon a number of factors:

- **Shutoff Pressure**
- Valve Unbalanced Area
- Valve Stroke
- Diaphragm Effective Area
- Controller Supply Pressure
- Valve Action

See glossary for definition of these terms.

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CONSTRUCTION

P25, P50, P110 — Single-spring diaphragm, die-cast aluminum

P30, P60 — Multi-spring design, steel housing for use in areas where aluminum is not suitable. Low-profile design for installation where space is limited.

ACTUATOR SELECTION

The actuator must have a large enough diaphragm effective area to permit shutoff against line pressure and a spring which is stiff enough (has high enough gradient) to precisely position the valve plug in response to incremental changes in controller output. The table below lists the effective area and stroke for each actuator type.

Actuator Type	Diaphragm Effective Area		Stroke	
	m^2	in^2	mm	in
P25	0.016	25	19	0.75
P30	0.019	30	19	0.75
P50	0.032	50	38	1.50
P60	0.035	54	19	0.75
P110	0.071	110	57	2.25

It is important to realize that although the linear output of a controller is nominally 3 to 15 psi or 6 to 30 psi, the actual available output span is much wider. The minimum output is 0.5 psi due to some leakage through the relay. Maximum output of 18 or 32 psi is chosen to reflect line losses from the controller to the valve. Thus with a 20 psi air supply the actual output range is 0.5 to 18 psi. An air supply of 35 psi has an actual output range of 0.5 to 32 psi.

Actuator selection is based on these wider, more realistic output ranges, affording a more precise selection of actuator and spring for each application.

There are two "rules of thumb" used in actuator selection.

1. If air-to-open action is desired, the amount of initial compressive force of the spring (spring initial) must be enough to overcome the effect of line pressure plus either 2 psi or 25% of the theoretical spring initial, whichever is larger, to ensure tight shutoff.
2. If air-to-close action is desired, spring initial tends to keep the plug off the seat. For this reason, a minimum spring initial of 1 psi on the diaphragm is applied. After the valve is fully stroked, the remainder of the controller output signal is used for seating force.

FORCES

The following vector diagrams (Figures 1 and 2) give schematic representation of forces, when the valve is shut off, for each of the two valve actions for valves in which the flow enters under the seat.

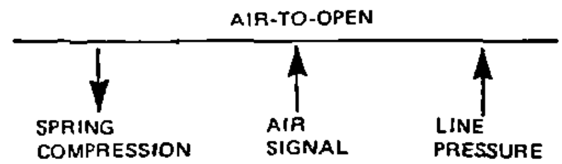

Figure 1

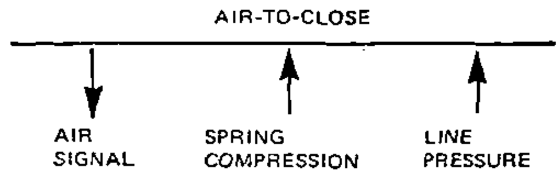

Figure 2

Using these diagrams as a guide, actuator selection and calibration is simplified.

It is important to note that as the valve opens, the force due to line pressure is decreased. When the valve is shut off, Figure 3, this force is maximum. At full open, Figure 4, the force due to the line pressure is largely dissipated and the force against the plug is negligible. Figure 5 shows this graphically.

The following examples outline the steps and considerations which are taken in the selection of actuators and spring assemblies.

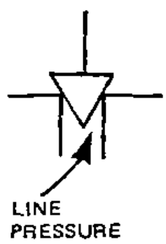

Figure 3

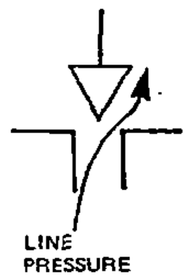

Figure 4

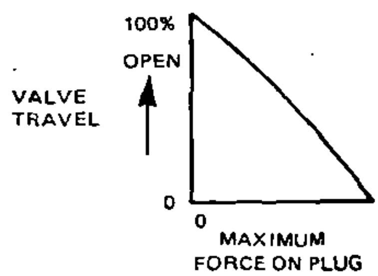

Figure 5

Example 1: (See Figure 6)

A valve with a 1 in^2 unbalanced area has been selected to shut off against 100 psi. Valve stroke length is 0.625 in. Controller air supply is 20 psi and air-to-open action is desired. What actuator and spring assembly should be used and what is the bench calibration span?

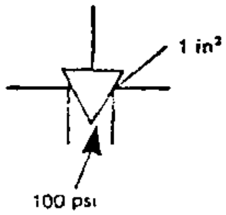

Figure 6

When the valve is shut off, the upward force due to line pressure = (100 psi) (1 in^2) = 100 lb.

The stroke length is only 0.625 in. Therefore, the P25, P30, P50, P60, or P110 Actuator can supply the required travel (see table on Page 2). By dividing the effective area of the diaphragm into the upward force, we get the amount of spring initial required to just balance the upward force of line pressure. For each actuator, the spring initial pressure is:

P25, $\frac{100\ lb}{25\ in^2} = 4$ psi; P30, $\frac{100\ lb}{30\ in^2} = 3.3$ psi

P50, $\frac{100\ lb}{50\ in^2} = 2$ psi; P60, $\frac{100\ lb}{54\ in^2} = 1.8$ psi

P110, $\frac{100\ lb}{110\ in^2} = 0.91$ psi;

Each actuator is capable of shutting off the valve against 100 lbs of force. From an economic standpoint, the P25 Actuator is the best choice.

A 4 psi spring initial (P25) will just balance the force from line pressure. An additional 2 psi is applied to ensure tight shutoff. A signal pressure of 6 psi, therefore, is applied to the actuator on the bench and the spring adjusting nut is tightened until the actuator just seats. See Figure 7.

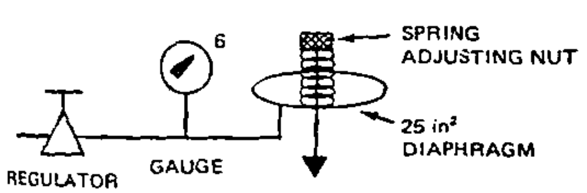

Figure 7

We must now choose a spring that has a spring rate which will stroke 0.625 inch as the signal pressure goes from 6 psi to the 18 psi maximum, a 12 psi span. Gradient is defined as force change per inch of travel, $G = \Delta F/in$. To determine gradient, we use the formula:

$$G = \frac{(A)\,(P)}{S}$$

A = Actuator Area (in^2)
P = Bench Span (Δ psi or Δ F/in^2)
S = Valve Stroke (in)

$$G = \frac{(in^2)\,(\Delta F/in^2)}{in} = \Delta F/in$$ which is the definition of gradient.

For our example we need a spring with a gradient equal to:

$$G = \frac{(in^2)\,(\Delta\ psi)}{in} \quad \text{or}$$

$$G = \frac{(25\ in^2)\,(12\ psi)}{0.625\ in} = 480\ lb/in$$

A spring with this gradient will stroke our valve 0.625 in with a 6 to 18 psi bench span. When it is in the line, operating air signal will be from 2 to 18 psi.

Refer to Foxboro for the part number of the spring with the correct spring rate.

Example 2:

Because the P Series Actuators are reversible, consider the same conditions as in Example 1, except air-to-close action is desired. From Example 1 we know that the P25 spring and actuator assembly will stroke 0.625 in with a 12 psi bench span. Air-to-close actuators have a minimum of 1 psi bench spring initial. This actuator will be calibrated 1 to 13 psi on the bench. When the actuator is in the line and fully stroked, that is, just closed, there will be a force due to spring compression equal to (480 lb/in) (0.625 in) = 300 lb plus the one psi spring initial force which adds another 25 lb of force tending to open the valve. Air pressure on the actuator must overcome this 325 lb plus the 100 lb force due to line pressure, or a total force of 425 lb. An air signal of

$$\frac{425\ lb}{25\ in^2} = 17\ psi$$

must be applied to shut off this valve against 100 psi line pressure. Controller output signal above 17 psi will give additional seating force.

These examples outline the general methods used in selecting spring-diaphragm actuators for globe-type valves, such as the Foxboro V1 and V1400U. Actuator selection for other valve types; Ball, Butterfly, and Saunders is much more complex. Refer to Foxboro for the methods used to select actuators for these valve types.