ITS
Institut Teknologi Sepuluh Nopember

TUGAS AKHIR RF 0469

SISTEM MONITORING TEMPERATUR DAN KECEPATAN MOTOR PADA MINI PLANT DAUR ULANG PLASTIK

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PROGRAM STUDI D3 TEKNIK INSTRUMENTASI
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Institut Teknologi Sepuluh Nopember
Surabaya
2009

ITS
Institut
Teknologi
Sepuluh Nopember

FINAL PROJECT RF 0469

BUILD AND DESIGN MONITORING SYSTEM OF TEMPERATURE AND ENGINE SPEED TO PLASTIC RECYCLING MINI PLANT

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2009

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SISTEM MONITORING *TEMPERATUR dan KECEPATAN MOTOR* PADA MINI PLANT DAUR ULANG PLASTIK DI WORKSHOP INSTRUMENTASI

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Surabaya, Agustus 2009

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SISTEM MONITORING *TEMPERATUR* PADA MINI PLANT DAUR ULANG PLASTIK DI WORKSHOP INSTRUMENTASI

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Memperoleh Gelar Ahli Madya
pada
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RANCANG BANGUN SISTEM MONITORING TEMPERATUR DAN KECEPATAN MOTOR PADA MINI PLANT DAUR ULANG PLASTIK

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Abstrak

Sistem monitoring temperature dan rpm motor pada miniplant daur ulang plastic sudah digunakan dalam dunia industri skala besar maupun home industri. Pada system monitoring variabel temperature dan variable kecepatan motor pada miniplant mesin daur ulang plastic ini menggunakan thermocontrol dan mikrokontroller sebagai fungsi monitoring kerja system. Perancangan disini bertujuan untuk memberikan tampilan pada proses pelelehan material plastic. Sensor temperature pada system ini menggunakan thermocouple. Dan display menggunakan sensor bimetal. Untuk kecepatan motor (RPM) menggunakan sensor reed switch, dimana sensor reed swicth itu diproses oleh mikrokontroller agar dapat ditampilkan pada *LCD*. Metoda miniplant daur ulang plastik ini yaitu dengan cara proses eksterusi, dengan pemanasan 190 ^{0}C hingga 200 ^{0}C dengan rata-rata waktu yang diperlukan 16 sampai dengan 20 menit untuk proses pelelehan plastic.

Kata kunci :Monitoring Temperatur, Monitoring RPM motor, Heater, srew extruder.

BUILD AND DESIGN MONITORING SYSTEM OF TEMPERATURE AND ENGINE SPEED TO PLASTIC RECYCLING MINI PLANT

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Abstract

System monitoring temperature and rpm motor miniplant recycled plastic is used in the industry and large-scale home industries. In the variable temperature monitoring system and variable speed motor on the engine miniplant recycling plastic uses thermocontrol and mikrokontroller as a function of the monitoring system. The design here is to give the appearance of the melting plastic material process. Temperature sensor in the system using this thermocouple. Display and use the bimetal sensor. For speed motor (RPM) using the Reed switch sensor, where the sensor is processed Reed swicth by mikrokontroller that can be displayed on the LCD. Method miniplant recycled plastic that the way is this process eksterusi, with heating 190 ^{0}C until 200 ^{0}C and the average time that required 16 until 20 minutes to process melting plastic.

Keywords : Temperature Monitoring, Monitoring RPM motor, Heater, srew extruder..

KATA PENGANTAR

Puji syukur Alhamdulillah atas berkah dan rahmat yang diberikan Allah SWT, karena atas petunjuk, karunia, dan ridlo-Nya lah penulis mampu untuk melaksanakan dan menyelesaikan tugas akhir dengan judul :

SISTEM MONITORING *TEMPERATUR dan KECEPATAN MOTOR* PADA MINI PLANT DAUR ULANG PLASTIK DI WORKSHOP INSTRUMENTASI

Tugas akhir ini disusun guna memenuhi persyaratan bagi seorang mahasiswa untuk memperoleh gelar Ahli Madya pada Program Studi D3 Teknik Instrumentasi Jurusan Teknik Fisika, Fakultas Teknologi Industri Institut Teknologi Sepuluh Nopember Surabaya.

Selama pengerjaan tugas akhir ini penulis telah banyak mendapatkan bantuan dari berbagai pihak. Oleh karena itu pada kesempatan ini penulis ingin mengucapkan terima kasih yang sebesar-besarnya kepada :

1. Keluarga besar saya, atas kasih sayang dan do'a Orang Tua yang telah diberikan selama ini yang menjadikan penulis tidak hanya sekedar mampu menyelesaikan tugas akhir ini namun mampu menjadikan penulis sebagai orang yang berarti dalam hidup.
2. Bapak Ir. Sarwono beserta keluarga selaku Kalab Laboratorium Energi dan Pembimbing Tugas Akhir yang telah memberikan segenap bimbingan, kesabaran, dan ilmu yang tiada ternilai harganya.
3. Bapak Dr. Bambang Lelono W. ST.MT. selaku Ketua Jurusan Teknik Fisika dan Dosen Wali penulis.
4. Teman-teman angkatan 2006 khususnya dan teman-teman angkatan 2007/2008 pada umumnya yang telah memberikan dorongan moral.

5. Terima kasih Shylfia yang telah memberikan support selama ini.
6. Terima kasih kepada teman-teman alumni GIKI II yang telah memberikan dorongan support.

Penulis menyadari bahwa tugas akhir ini tidaklah sempurna, tetapi penulis berharap tugas akhir ini dapat memberikan kontribusi yang berarti dan dapat menambah wawasan bagi pembaca dan mahasiswa D3 Teknik Instrumentasi yang nanti dapat digunakan sebagai referensi pengerjaan tugas akhir baru. Semoga awal dari permulaan yang panjang ini dapat membawa manfaat dan hikmah bagi kita semua dan juga semoga hari esok lebih baik dari hari ini.

Amin...

Surabaya, Juni 2009

Penulis

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BAB I
PENDAHULUAN

1.1 Latar Belakang

Plastik adalah suatu polimer yang mempunyai sifat-sifat elastis

Polimer alam yang telah kita kenal antara lain : selulosa, protein, karet alam dan sejenisnya. Pada mulanya manusia menggunakan polimer alam hanya untuk membuat perkakas dan senjata, tetapi keadaan ini hanya bertahan hingga akhir abad 19 dan selanjutnya manusia mulai memodifikasi polimer menjadi plastik.

Secara garis besar, plastik dapat dikelompokkan menjadi dua golongan, yaitu : plastik thermoplast dan plastik thermoset. Plastik thermoplast adalah plastik yang dapat dicetak berulang-ulang dengan adanya panas. Yang termasuk plastic thermoplast antara lain : PE, PP, PS, ABS, SAN, nylon, PET, BPT, Polyacetal (POM), PC dll. Sedangkan palstik thermoset adalah plastik yang apabila telah mengalami kondisi tertentu tidak dapat dicetak kembali karena bangun polimernya berbentuk jaringan tiga dimensi. Yang termasuk plastic thermoset adalah : PU (Poly Urethene), UF (Urea Formaldehyde), MF (Melamine Formaldehyde), polyester, epoksi dll.

Pada tugas akhir ini penulis merancang suatu teknologi untuk mengatasi masalah limbah plastik yang lama diurai oleh alam, maka dari itu dibuat sistem rancangan daur ulang plastik dengan menggunakan pemanas screw extruder. Dimana sistem ini menekan plastik seperti mesin bor dan dindingnya terdapat pemanas yang dapat dengan suhu yang telah ditentukan dan dapat melelehkan plastik jenis PP.

1.2 Permasalahan

Untuk memperoleh hasil yang baik pada pemanasan plastik perlu adanya suhu atau temperatur yang sesuai dengan

karakteristik dari material plastik yang akan dipanaskan. Pada tugas akhir ini permasalahan yang akan dibahas adalah bagaimana merancang sebuah sistem pemanas pada screw extruder pelelehan plastik dapat diset sesuai dengan material plastik yang akan diproses. Agar hasil dari outputnya sesuai dengan yang diinginkan untuk dapat diproses daur ulang.

1.3 Batasan Permasalahan

Perlu diberikan beberapa batasan permasalahan dengan tujuan agar pembahasan tidak meluas dan menyimpang dari tujuan. Adapun batasan permasalahan dari sistem yang dirancang ini adalah :

- Sistem ini dirancang dan dijalankan pada real plant.
- Sistem yang dirancang adalah sistem daur ulang plastik bekas jenis PP PoliPropelen (Polimer Propelen).
- Menggunakan elemen pemanas Heater
- Sensor yang digunakan thermocouple dengan suhu antara 120-160 °C.
- Hasil yang diperoleh memanjang dan diproses secara manual.
- Motor jalan secara secara kontinue.

1.4 Sistematika Laporan

Bab I PENDAHULUAN

Berisi tentang latar belakang sistem daur ulang plastik dengan srew extruder, permasalahan, batasan masalah, tujuan dan manfaat, metodologi tugas akhir, dan sistematika laporan.

Bab II TEORI PENUNJANG

Berisi tentang dasar teori *sistem dan monitoring temperatur dan kecepatan motor pada mesin pelet plastik* dan minimum sistem Mikrokontroler AVR

Atmega 8535 serta *hardware* elektronik penunjang sistem.

Bab III METODOLOGI PENELITIAN

Berisi tentang langkah-langkah analisa yang akan dilakukan selama tugas akhir, diantaranya adalah perancangan *sistem dan monitoring temperatur dan kecepatan motor pada mesin pelet plastik* perancangan *hardware* elektronika untuk kepentingan proses kontrol, perancangan *software*, pengujian, dan analisa sistem.

Bab IV HASIL DAN ANALISA

Berisi tentang hasil perancangan *sistem dan monitoring temperatur dan kecepatan motor pada mesin pelet plastik* secara keseluruhan, pengujian hardware dan pengujian sistem serta analisa

Bab V KESIMPULAN DAN SARAN

Berisi tentang hasil yang diperoleh dari analisa sistem, analisa data, dan saran.

BAB II
LANDASAN TEORI

Pada bab II akan dibahas mengenai beberapa dasar teori yang menunjang perancangan sistem perajang plastik pada miniplant mesin pelet plastik, antara lain : mikrokontroller AVR 8535L, bahan baku plastik, motor, heater, riley, sensor thermocouple dan optocoupler.

2.1 Deskripsi Plastik

Plastik adalah suatu polimer tinggi yang dicetak dalam lembaran-lembaran yang mempunyai ketebalan berbeda-beda. Para praktikkum kali ini dilakukan pengujian terhadap plastic agar dapat menentukan jenisnya melalui uji burning out, selain itu dilakukan pula uji deskripsi, penentian berat, ketebalan hingga densitas. Plastik mencakup produk polimerisasi sintetik atau semi-sintetik yang terbentuk dari kondensasi organik atau penambahan polimer dan bisa juga terdiri dari zat lain untuk meningkatkan performa atau ekonomi. Plastik adalah polimer; rantai-panjang atom mengikat satu sama lain. Rantai ini membentuk banyak unit molekul berulang, atau "monomer". Plastik yang umum terdiri dari polimer karbon saja atau dengan oksigen, nitrogen, chlorine atau belerang di tulang belakang. (beberapa minat komersial juga berdasar silikon). Tulang-belakang adalah bagian dari rantai di jalur utama yang menghubungkan unit monomer menjadi kesatuan. Plastik dapat digunakan dalam bentuk lembaran dan bentuk wadah yang dapat dicetak, hal ini berhubungan dengan penggolongan kemasan dimana plastic dapat dimasukkan sebagai kemasan tegar dan lentur. Dalam praktikkum ini plastik yang diamati ada beberapa jenis ada yang berbentuk film dan bentuk botol plastic (air mineral). Bahan pertama pembuat pastik adalah resin, baik alami maupun sintetik. Jenis plastik sendiri beraneka ragam, ada Polyethylene, Polypropylen, Poly Vinyl Chlorida (PVC), dan Vinylidene Chloride Resin.

Sifat plastik pada dasarnya adalah antara serat dan elastomer. Jenis plastik dan penggunaannya sangat luas. Plastik yang banyak digunakan berupa lempeng, lembaran dan film. Ditinjau dari penggunaannya plastik digolongankan menjadi dua yaitu plastik keperluan umum dan plastik untuk bahan konstruksi (*engineering plastics*). Plastik mempunyai berbagai sifat yang menguntungkan, diantaranya:

a. Umumnya kuat namun ringan.
b. Secara kimia stabil (tidak bereaksi dengan udara, air, asam, alkali dan berbagai zat kimia lain).
c. Merupakan isolator listrik yang baik.
d. Mudah dibentuk, khusunya dipanaskan.
e. Biasanya transparan dan jernih.
f. Dapat diwarnai.
g. Fleksibel/plastis
h. Dapat dijahit.
i. Harganya relatif murah.

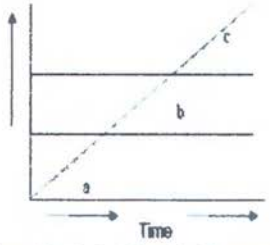
Beberapa contoh plastik yang banyak digunakan antara lain polietilen, poli(vinil klorida), polipropilen, polistiren, poli(metil pentena), poli (tetrafluoroetilen) atau teflon.

Sedangkan beberapa plastik lainnya mempunyai sifat-sifat tidak dapat larut dalam pelarut apapun, tidak meleleh jika dipanaskan, lebih tahan terhadap asam dan basa, jika dipanaskan akan rusak dan tidak dapat kembali seperti semula dan struktur molekulnya mempunyai ikatan silang antar rantai. Polimer seperti ini disusun secara permanen dalam bentuk pertama kali mereka dicetak, disebut **polimer termosetting**.

Plastik-plastik termosetting biasanya bersifat keras karena mereka mempunyai ikatan-ikatan silang. Plastik termoset menjadi lebih keras ketika dipanaskan karena panas itu menyebabkan ikatan-ikatan silang lebih mudah terbentuk. Bakelit, poli(melanin formaldehida) dan poli (urea formaldehida) adalah contoh polimer ini. Sekalipun polimer-polimer termoseting lebih sulit untuk dipakai ulang daripada termoplastik, namun polimer

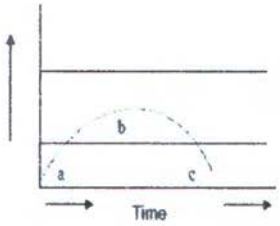
tersebut lebih tahan lama. Polimer ini banyak digunakan untuk membuat alat-alat rumah tangga yang tahan panas seperti cangkir. Perbedaan sifat-sifat plastik termoplas dan termoset disimpulkan pada perbedaan sifat plastik termoplas dan plastik termoset

Temperature



a. Start of process
b. Plastic melted
c. Plastic permanently

Grafik 2.1 Plastik Termoset



a. Start of process
b. Plastic melted
c. Plastic hard but can be softened

Polypropylene mempunyai titik leleh yang cukup tinggi (190 - 200 oC), sedangkan titik kristalisasinya antara 130 – 135 C. Polypropylene mempunyai ketahanan terhadap bahan kimia (hemical Resistance) yang tinggi, tetapi ketahanan pukul (impact strength) nya rendah.

Polypropylene merupakan polimer kristalin yang dihasilkan dari proses polimerisasi gas propilena. Propilena mempunyai specific gravity rendah dibandingkan dengan jenis plastik lain. Sebagai perbandingan terlihat pada Tabel 2.1

]

Tabel 2.1 Perbandinagan specific gravity dari berbagai material plastik.[1]

Resin	Specific gravity
PP	0,85-0,90
LDPE	0,91-0,93
HDPE	0,93-0,96
Polistirena	1,05-1,08
ABS	0,99-1,10
PVC	1,15-1,65
Asetil Selulosa	1,23-1,34
Nylon	1,09-1,14
Poli Karbonat	1,20
Poli Asetat	1,38

Plastik adalah barang yang sangat akrab dengan kehidupan kita. Tapi sadarkah bahwa ternyata tidak semua plastik aman untuk dipakai, apalagi sebagai wadah makanan. Baca tips di bawah ini untuk bisa membedakan plastik yang aman dan sehat, dan plastik yang berbahaya bagi kesehatan.

#1. PETE atau PET (polyethylene terephthalate)[2]

Contoh produk: botol minuman (misalnya Aqua). Produk-produk dengan bahan #1 dan #2 direkomendasikan hanya untuk sekali pakai. Jangan pakai untuk air hangat apalagi panas. Buang botol yang sudah lama atau terlihat baret-baret.

#2. HDPE (high density polyethylene) [2]

Produk: botol susu yang berwarna putih Sama seperti #1 PET, #2 juga direkomendasikan hanya untuk sekali pemakaian.

#3. V atau PVC (polyvinyl chloride) [2]

Contoh produk: cling wrap, botol Plastik yang paling sulit di daur ulang. Kandungan dari PVC yaitu DEHA yang terdapat pada plastik pembungkus dapat bocor dan masuk ke makanan berminyak bila dipanaskan. PVC berpotensi berbahaya untuk ginjal, hati dan berat badan.

#4. LDPE (low density polyethylene) [2]

Contoh produk: tempat makanan, botol botol yang lembek. Barang-barang dengan kode #4 dapat di daur ulang dan baik untuk barang-barang yang memerlukan fleksibilitas tetapi kuat. Barang dengan #4 bisa dibilang tidak dapat di hancurkan tetapi tetap baik untuk tempat makanan.

#5. PP (polypropylene) [2]

(polypropylene) adalah pilihan terbaik untuk bahan plastik terutama untuk yang berhubungan dengan makanan dan minuman seperti tempat menyimpan makanan, botol minum dan terpenting botol minum untuk bayi. Karakteristik adalah biasa botol transparan yang tidak jernih atau berawan. Cari simbol ini bila membeli barang berbahan plastik.

#6.PS(polystyrene) [2]

produk: tempat makan styrofoam, tempat minum sekali pakai, dll. Bahan Polystyrene bisa membocorkan bahan styrine ke dalam makanan ketika makanan tersebut bersentuhan. Bahan Styrine berbahaya untuk otak dan sistem syaraf. Selain tempat makanan, styrine juga bisa didapatkan dari asap rokok, asap kendaraan dan bahan konstruksi gedung. Bahan ini harus dihindari dan banyak negara bagian di Amerika sudah melarang pemakaian tempat makanan berbahan styrofoam termasuk negara China.

#7.Other(biasanyapolycarbonate) [2]

Contoh produk: tempat makanan dan minuman seperti botol minum olahraga. Polycarbonate bisa mengeluarkan bahan utamanya yaitu Bisphenol-A ke dalam makanan dan minuman

yang berpotensi merusak sistem hormon. Hindari bahan plastik Polycarbonate.

Khusus plastik dengan kode 1, 3, 6, dan 7 (polycarbonate), seluruhnya memiliki bahaya secara kimiawi. Ini tidah berarti bahwa plastik dengan kode yang lain secara utuh aman, namun perlu dipelajari lebih jauh lagi. Maka, jika kita harus menggunakan plastik, akan lebih aman bila menggunakan plastik dengan kode 2, 4, 5, dan 7 (kecuali polycarbonate) bila memungkinkan. Bila tidak ada kode plastik pada kemasan tersebut, atau bila tipe plastik tidak jelas (misalnya pada kode 7, di mana tidak selamanya berupa polycarbonate), cara terbaik yang paling aman adalah menghubungi produsennya dan menanyakan mereka tentang tipe plastik yang digunakan untuk membuat produk tersebut

Tabel 2.2 Temperature Leleh Proses termoplastik [3]

Processing Temperature Rate		
Material	oC	oF
ABS	180 - 240	356 – 464
Acetal	185 –225	365 – 437
Acrylic	180 – 250	356 – 482
Nylon	260 – 290	500 – 554
Poly Carbonat	280 – 310	536 - 590
LDPE	160 – 240	320 – 464
HDPE	200 – 280	392 – 536
PP	200 – 300	392 – 572
PS	180 – 260	356 – 500
PVC	160 - 180	320 – 365

2.2 MIKROKONTROLLER AVR ATmega8535

2.2.1 Arsitektur AVR ATmega8535

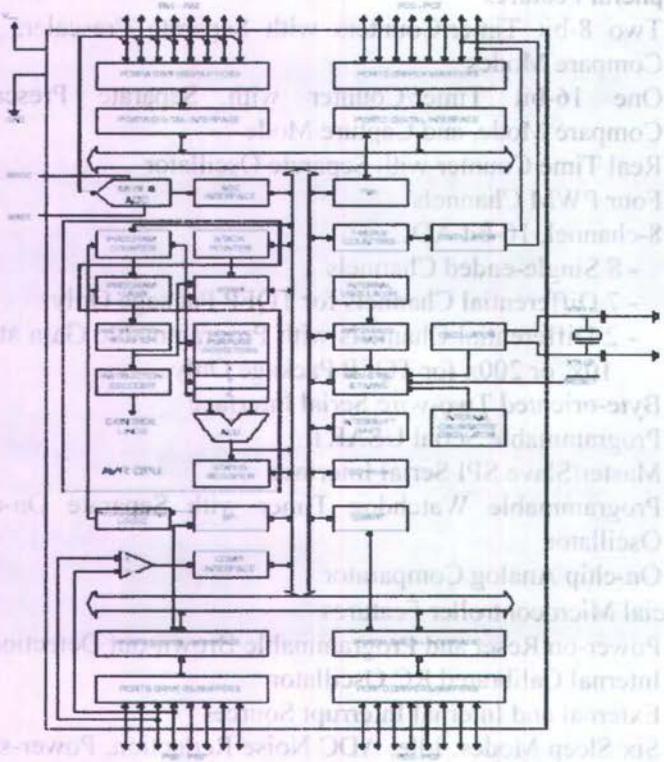
AVR merupakan seri mikrokontroller CMOS 8-bit buatan Atmel, berbasis arsitektur *RISC (Reduced Instruction Set*

Computer). Hampir semua instruksi dieksekusi dalam satu siklus clock. AVR mempunyai 32 register general-purpose, timer/counter fleksibel dengan mode compare, interupt internal dan eksternal, serial *UART*, programmable Watchdog Timer, dan mode power saving. Beberapa diantaranya mempunyai ADC dan PWM internal. AVR juga mempunyai In-System Programmable Flash on-chip yang mengijinkan memori program untuk diprogram ulang dalam sistem menggunakan hubungan serial SPI. Chip AVR yang digunakan untuk tugas akhir ini adalah ATmega8535.

ATmega8535 adalah mikrokontroller CMOS 8-bit daya-rendah berbasis arsitektur RISC yang ditingkatkan. Kebanyakan instruksi dikerjakan pada satu siklus clock, ATmega8535 mempunyai *throughput* mendekati 1 MIPS per MHz membuat disainer sistem untuk mengoptimasi komsumsi daya versus kecepatan proses. Blok diagram dari mikrokontroller dapat dilihat pada gambar 2.1 Mikrokontroller ATmega8535 memiliki sejumlah keistimewaan sebagai berikut :

- Advanced RISC Architecture
  - 130 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 8K Bytes of In-System Self-Programmable Flash
    - Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
    - In-System Programming by On-chip Boot Program
    - True Read-While-Write Operation
  - 512 Bytes EEPROM
    - Endurance: 100,000 Write/Erase Cycles
  - 512 Bytes Internal SRAM
  - Programming Lock for Software Security

- Peripheral Features
  - o Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - o One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - o Real Time Counter with Separate Oscillator
  - o Four PWM Channels
  - o 8-channel, 10-bit ADC
    - 8 Single-ended Channels
    - 7 Differential Channels for TQFP Package Only
    - 2 Differential Channels with Programmable Gain at 1x, 10x, or 200x for TQFP Package Only
  - o Byte-oriented Two-wire Serial Interface
  - o Programmable Serial USART
  - o Master/Slave SPI Serial Interface
  - o Programmable Watchdog Timer with Separate On-chip Oscillator
  - o On-chip Analog Comparator
- Special Microcontroller Features
  - o Power-on Reset and Programmable Brown-out Detection
  - o Internal Calibrated RC Oscillator
  - o External and Internal Interrupt Sources
  - o Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Powerdown, Standby and Extended Standby
- I/O and Packages
  - o 32 Programmable I/O Lines
  - o 40-pin PDIP, 44-lead TQFP, 44-lead PLCC, and 44-pad MLF
- Operating Voltages
  - o 2.7 - 5.5V for ATmega8535L
  - o 4.5 - 5.5V for ATmega8535
- Speed Grades
  - o 0 - 8 MHz for ATmega8535L
  - o 0 - 16 MHz for ATmega8535

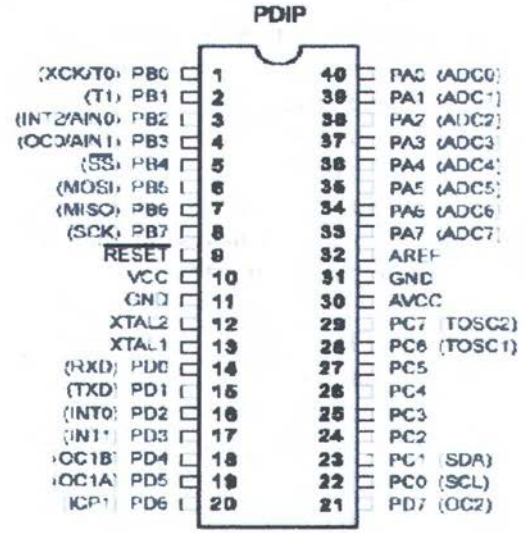


Gambar 2.1
Blok Diagram Mikrokontroller ATmega8535

2.2.2 Pena - Pena ATmega8535

Konfigurasi Pin Mikrokontroller ATmega8535 dengan kemasan 40-pin DIP (dual in-line package) dapat dilihat pada Gambar 2.2. Untuk memaksimalkan performa dan paralelisme, AVR menggunakan arsitektur Harvard (dengan memori dan bus terpisah untuk program dan data). Arsitektur CPU dari AVR ditunjukkan oleh gambar 2.3 Instruksi pada memori program dieksekusi dengan pipelining single level. Selagi sebuah instruksi

sedang dikerjakan, instruksi berikutnya diambil dari memori program.



Gambar 2.2.
Konfigurasi Pin Mikrokontroller ATmega8535

2.2.3 Deskripsi Mikrokontroller ATmega8535

- VCC *(power supply)*
- GND *(ground)*
- Port A (PA7..PA0)

  Port A berfungsi sebagai *input* analog pada A/D Konverter. Port A juga berfungsi sebagai suatu Port I/O 8-bit dua arah, jika A/D Konverter tidak digunakan. Pin - pin Port dapat menyediakan resistor *internal pull-up* (yang dipilih untuk masing-masing bit). Port A *output buffer* mempunyai karakteristik gerakan simetris dengan keduanya *sink* tinggi dan kemampuan sumber. Ketika pin PA0 ke PA7 digunakan sebagai *input* dan secara *eksternal* ditarik rendah, pin – pin akan memungkinkan arus sumber jika resistor *internal pull-up* diaktifkan. Pin Port A adalah *tri-*

stated manakala suatu kondisi reset menjadi aktif, sekalipun waktu habis.

- Port B (PB7..PB0)
  Port B adalah suatu Port I/O 8-bit dua arah dengan resistor internal pull-up (yang dipilih untuk beberapa bit). Port B *output buffer* mempunyai karakteristik gerakan simetris dengan keduanya *sink* tinggi dan kemampuan sumber. Sebagai input, pin port B yang secara *eksternal* ditarik rendah akan arus sumber jika resistor *pull-up* diaktifkan. Pin Port B adalah *tri-stated* manakala suatu kondisi reset menjadi aktif, sekalipun waktu habis.
- Port C (PC7..PC0)
  Port C adalah suatu Port I/O 8-bit dua arah dengan resistor internal pull-up (yang dipilih untuk beberapa bit). Port C *output buffer* mempunyai karakteristik gerakan simetris dengan keduanya *sink* tinggi dan kemampuan sumber. Sebagai input, pin port C yang secara *eksternal* ditarik rendah akan arus sumber jika resistor *pull-up* diaktifkan. Pin Port C adalah *tri-stated* manakala suatu kondisi reset menjadi aktif, sekalipun waktu habis.
- Port D (PD7..PD0)
  Port D adalah suatu Port I/O 8-bit dua arah dengan resistor internal pull-up (yang dipilih untuk beberapa bit). Port D *output buffer* mempunyai karakteristik gerakan simetris dengan keduanya *sink* tinggi dan kemampuan sumber. Sebagai input, pin port D yang secara *eksternal* ditarik rendah akan arus sumber jika resistor *pull-up* diaktifkan. Pin Port D adalah *tri-stated* manakala suatu kondisi reset menjadi aktif, sekalipun waktu habis.
- RESET *(Reset input)*
- XTAL1 *(Input Oscillator)*
- XTAL2 *(Output Oscillator)*
- AVCC adalah pin penyedia tegangan untuk port A dan A/D Konverter
- AREF adalah pin referensi analog untuk A/D konverter.

2.2.4. Port Sebagai Input / Output Digital

ATmega8535 mempunyai empat buah port yang bernama PortA, PortB, PortC, dan PortD. Keempat port tersebut merupakan jalur bi-directional dengan pilihan internal pull-up.

Tiap port mempunyai tiga buah register bit, yaitu DDxn, PORTxn, dan PINxn. Huruf 'x' mewakili nama huruf dari port sedangkan huruf 'n' mewakili nomor bit. Bit DDxn terdapat pada I/O address DDRx, bit PORTxn terdapat pada I/O address PORTx, dan bit PINxn terdapat pada I/O address PINx. Bit DDxn dalam regiter DDRx (Data Direction Register) menentukan arah pin. Bila DDxn diset 1 maka Px berfungsi sebagai pin output. Bila DDxn diset 0 maka Px berfungsi sebagai pin input. Bila PORTxn diset 1 pada saat pin terkonfigurasi sebagai pin input, maka resistor pull-up akan diaktifkan. Untuk mematikan resistor pull-up, PORTxn harus diset 0 atau pin dikonfigurasi sebagai pin output. Pin port adalah tri-state setelah kondisi reset. Bila PORTxn diset 1 pada saat pin terkonfigurasi sebagai pin output maka pin port akan berlogika 1. Dan bila PORTxn diset 0 pada saat pin terkonfigurasi sebagai pin output maka pin port akan berlogika 0.

Saat mengubah kondisi port dari kondisi *tri-state* (DDxn=0, PORTxn=0) ke kondisi *output high* (DDxn=1, PORTxn=1) maka harus ada kondisi peralihan apakah itu kondisi *pull-up enabled* (DDxn=0, PORTxn=1)atau kondisi *output low* (DDxn=1, PORTxn=0). Biasanya, kondisi pull-up enabled dapat diterima sepenuhnya, selama lingkungan impedansi tinggi tidak memperhatikan perbedaan antara sebuah *strong high driver* dengan sebuah pull-up. Jika ini bukan suatu masalah, maka bit PUD pada register SFIOR dapat diset 1 untuk mematikan semua *pull-up* dalam semua port. Peralihan dari kondisi *input dengan pull-up* ke kondisi *output low* juga menimbulkan masalah yang sama. Maka harus menggunakan kondisi tri-state (DDxn=0, PORTxn=0) atau kondisi output high (DDxn=1, PORTxn=0) sebagai kondisi transisi. Lebih detil mengenai port ini dapat dilihat pada manual datasheet dari IC ATmega8535.

Tabel 2.3 Konfigurasi Pin Port

DDxn	PORTxn	PUD (in SFIOR)	I/O	Pull-up	Comment
0	0	X	Input	No	Tri-state (Hi-Z)
0	1	0	Input	Yes	Pxn will source current if ext. pulled low.
0	1	1	Input	No	Tri-state (Hi-Z)
1	0	X	Output	No	Output Low (Sink)
1	1	X	Output	No	Output High (Source)

Bit	7	6	5	4	3	2	1	0	
	ADTS2	ADTS1	ADTS0	–	ACME	PUD	PSR2	PSR10	SFIOR
Read/Write	R/W	R/W	R/W	R	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

Bit 2 – PUD : Pull-up Disable

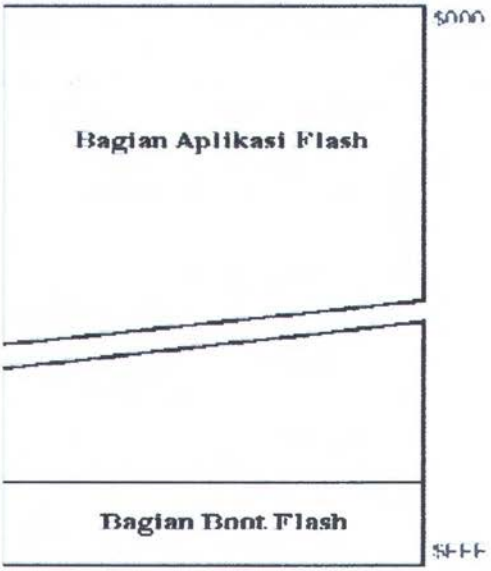
Bila bit diset bernilai 1 maka pull-up pada port I/O akan dimatikan walaupunregister DDxn dan PORTxn dikonfigurasikan untuk menyalakan pull-up (DDxn=0, PORTxn=1).

2.2.5. Organisasi Memori AVR ATmega8535

AVR arsitektur mempunyai dua ruang memori utama, Ruang Data Memori dan Ruang Program Memori. Sebagai tambahan, ATmega8535 memiliki fitur suatu EEPROM Memori untuk penyimpanan data. Semua tiga ruang memori adalah reguler dan linier.

2.2.5.1. Program Memori

ATmega8535 berisi 8K bytes On-Chip di dalam sistem Memori flash Reprogrammable untuk penyimpanan program. Karena semua AVR instruksi adalah 16 atau 32 bits lebar, Flash adalah berbentuk 4K x 16. Untuk keamanan perangkat lunak, Flash Ruang program memori adalah dibagi menjadi dua bagian, bagian boot program dan bagian aplikasi program. Flash Memori mempunyai suatu daya tahan sedikitnya 10,000 write/erase Cycles. ATmega8535 Program Counter (PC) adalah 12 bit lebar, alamat ini 4K lokasi program memori.

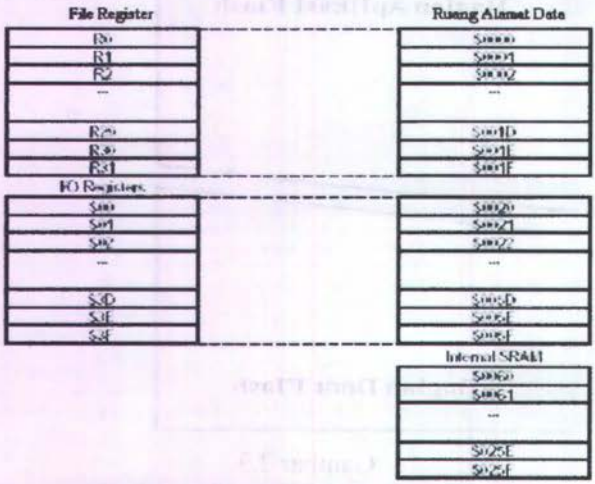


Gambar 2.3.
Pemetaan Program Memori

2.2.5.2. Data Memori

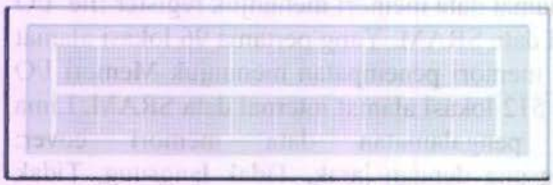
608 lokasi alamat data memori menunjuk register file, I/O memori, dan internal data SRAM. Yang pertama 96 lokasi alamat file register dan I/O memori penempatan menunjuk Memori I/O dan yang berikutnya 512 lokasi alamat internal data SRAM. Lima perbedaan mode pengalamatan data memori cover: Langsung,Tidak langsung dengan jarak, Tidak langsung, Tidak langsung dengan Pre-Decrement, dan Tidak langsung dengan Post-Increment. Di dalam file register, register R26 ke R31 memiliki fitur penunjukan pengalamatan register tidak langsung. Jangkauan pengalamatan langsung adalah keseluruhan ruang data. Mode Tidak langsung dengan jarak jangkauan 63 lokasi alamat dari alamat dasar yang diberi oleh Y- atau Z-Register. Manakala penggunaan register mode tidak langsung dengan pre-decrement otomatis dan postincrement, alamat register X, Y, dan Z adalah

decremented atau incremented. 32 tujuan umum kerja register, 64 I/O register, dan 512 bytes data internal SRAM di dalam ATmega8535 adalah semua dapat diakses melalui semua mode pengalamatan.



Gambar 2.4 Pemetaan Data Memori

2.3 Blok display LCD



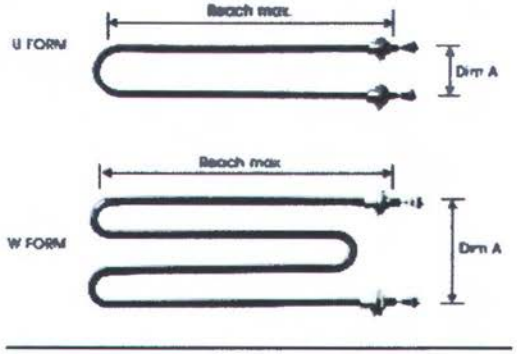
Gambar 2.5 Blok LCD

Program yang dijalankan pada blok mikrokontroler akan ditampilkan pada blok LCD. Dengan ukuran 2 X 16 akan mampu menampilkan karakter sebanyak 16 buah dalam dua baris. Display ini membutuhkan 20 pin yang terbagi dalam konektor 1

dan konektor 3 dari blok mikrokontroler. Konektor 1 berfungsi sebagai kontrol dan konektor yang ke dua sebagai data bagi LCD. Untuk konektor bisa menggunakan konektor selain yang sudah di rekomendasikan untuk itu program driver LCD perlu di modifikasi.

2.4 Elemen Heater

Pada system heater untuk mempertahankan suhu pada suatu nilai tertentu digunakan bagian pemanas *(heater)*. Pemanas ini dibentuk dengan menggunakan kawat nikelin. Pada system heater ini menggunakan turbular heater, yang dimana tubular heater ini biasanya memang dipakai untuk aplikasi pemanas pada bentuk pipa.



Gambar 2.6 Elemen Heater

Bahan	: ss304, incoloy
Diameter	: 8,11 mm
Panjang	: sampai dengan 3500 mm
Penggunaan listrik	: Max. 77,5 Kw/m^2 air bersih
	Max. 46,5 Kw/ m^2
	Max. 31 Kw/m^2 oli

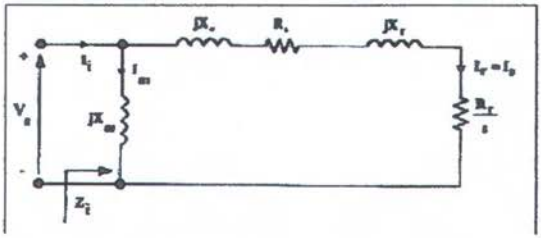
2.5 Motor

Motor Induksi Phasa Satu

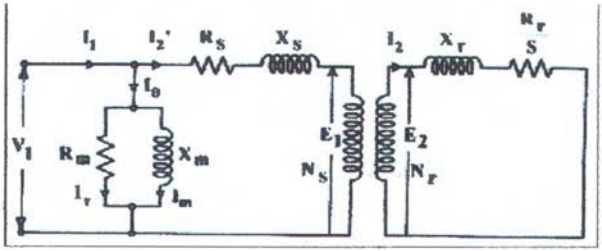
Gambar 2.7 Konstruksi motor induksi satu fasa

Konstruksi motor induksi satu fasa terdiri atas dua komponen yaitu stator dan rotor. Stator. adalah bagian dari motor yang tidak bergerak dan rotor adalah bagian yang bergerak yang bertumpu pada bantalan poros terhadap stator. Motor induksi terdiri atas kumparan-kumparan stator dan rotor yang berfungsi membangkitkan gaya gerak listrik akibat dari adanya arus listrik bolak-balik satu fasa yang melewati kumparan-kumparan tersebut sehingga terjadi suatu interaksi induksi medan magnet antara stator dan rotor. Bentuk dan konstruksi motor tersebut digambarkan pada gambar 2.7

Rangkaian Ekivalen Motor Induksi Phasa Satu Motor induksi satu fasa terdiri kumparan stator dan kumparan rotor. Kumparan stator dan rotor masing-masing terdiri dari parameter resistansi "R', reaktansi "jX"dan lilitan penguat "N". rangkaian ekivalen dari motor induski satu fasa dapat dilihat pada gambar di bawah ini.



Gambar 2.8 Rangkaian ekivalen motor induksi sederhana.



Gambar 2.9 Rangkaian pengganti motor induksi satu fasa.

Nilai arus suber bolak-balik satu fasa dapat dirumuskan sebagai berikut :

$I_1 = I_\emptyset + I_2$ (1)

Besarnya arus pemaknitan *IØ* yang timbul akibat adanya induksi yang terjadi antara medan stator dan rotor adalah :

$I_\emptyset = I_r + I_m$ (2)

Gambar 2.7 Konstruksi motor induksi satu fasa Konstruksi motor induksi satu fasa terdiri atas dua komponen yaitu stator dan rotor. Stator adalah bagian dari motor yang tidak bergerak dan rotor adalah bagian yang bergerak yang bertumpu pada bantalan poros terhadap stator. Motor induksi terdiri atas kumparan-kumparan stator dan rotor yang berfungsi membangkitkan gaya gerak listrik akibat dari adanya arus listrik bolak-balik satu fasa yang melewati kumparan-kumparan tersebut sehingga terjadi suatu interaksi induksi medan magnet antara stator dan rotor. Bentuk dan konstruksi motor tersebut digambarkan pada gambar 2.7.

Prinsip Kerja Motor Induksi Phasa Satu Apabila kumparan-kumparan motor induksi satu fasa dialiri arus bolak-balik satu fasa, maka pada celah udara akan dibangkitkan medan yang berputar dengan kecepatan putaran sebesar dengan menggunakan rumus :

$$n_s = \frac{120.f}{p} \quad \frac{putaran}{menit} [ppm] \qquad (3)$$

Atau

$$\omega_s = \frac{2\pi f}{p} \qquad (4)$$

Medan magnet berputar bergerak memotong lilitan rotor sehingga menginduksikan tegangan listrik pada kumparan-kumparan tersebut. Biasanya lilitan rotor berada dalam hubung singkat. Akibatnya lilitan rotor akan mengalir arus listrik yang besarnya tergantung pada besarnya tegangan induksi dan impedansi rotor. Arus listrik yang mengalir pada rotor akan mengakibatkan medan magnet rotor dengan kecepatan sama dengan kecepatan medan putar stator (ns). interkasi medan stator dan rotor akan membangkitkan torsi yang menggerakkan rotor berputar searah dengan arah medan putar stator. Interaksi medan stator dan rotor juga menyebabkan terjadinya ggl induksi yang disebabkan oleh kumparan-kumparan stator dan rotor.

2.6 Relay

Relay adalah peralatan yang menggunakan elektromagnet dalam memberikan gaya untuk membuka atau menutup switch. Dengan kata lain, suatu switch dengan menggunakan tenaga elektris. Suatu switch atau relay pada saat keadaan tidak fiktif memiliki dua kondisi yaitu NO (*Normally Open*) dan NC (*Normally Close*). Dalam pemilihan suatu relay yang harus diperhatikan adalah kapasitas arusnya. Relay merupakan piranti control yang dapat berguna untuk menutup dan membuka kontak. Relay mekanis digunakan untuk menyambung atau memutuskan beban elektris. Proses *swithing* ini dikontrol oleh rangkaian

elektrik. Relay magnetic sering digunakan untuk mengontrol relay yang lain atau beban dengan daya yang kecil. Seringnya pengulangan membuka dan menutup, kontak dapat mengalami kerusakan akibat dari bunga api dan gesekan mekanis, sehingga bagian dari kontak tersebut dapat diganti dengan kontak yang baru. Hal ini sering terjadi terutama pada kontak magnetic. *Material-material* kontak yang sering digunakan adalah logam-logam khusus seperti Tembaga (Ag), Emas (Au), Platina (Pt), Nikel (Au-Ni) dan gabungan senyawa-senyawa seperti Ag-Au-Ni.

Sumber tegangan yang dipakai untuk dialirkan ke coil supaya terjadi gaya elektromagnetik adalah:

a. Sumber arus searah (DC)

Standar tegangan untuk relay DC adalah 6, 12, 24, 48, dan 100 (volt). Kinerja relay DC lebih mantap karena kecepatan *switching* relay DC lebih rendah dibandingkan dengan relay AC karena induktansi dari koil menekan kecepatan menaikkan arus. Kerugiannya adalah memerlukan catu daya DC yang khusus.

b. Sumber arus bolak balik

Relay AC biasanya dieksitasi dengan sumber tegangan 100 atau 200 (V) dengan frekuewnsi 50 atau 60 (Hz). Pada arus bolak-balik panas dapat terjadi pada kumparan dan inti besi. Untuk catu tegangan yang lebih rendah dari tegangan minimum yang diijinkan akan terjadi desah dan kinerjanya tidak stabil. Untuk sumber daya arus searah (DC) lebih stabil artinya pada koil tidak terjadi getaran karena sumber DC tidak dipengaruhi oleh adanya frekuensi.

Pada relay DC ini kontaktornya tidak bergetar sehingga mempunyai usia pakai yang lama. Untuk sumber daya arus bolak-balik (AC) kurang stabil sehingga terjadi cattering atau getaran pada kontaknya karena sumber daya AC pada koil yang mempunyai frekuensi yaitu antara 50 – 60 Hz. Karena adanya pengaruh frekuensi ini pada sumber daya kontrolnya maka usia pakai kontak (baik NC maupun NO) relay AC tidak untuk waktu yang cukup lama atau cepat sekali aus.

Gambar 2.10 *Relay* DC

2.7 Thermocuple

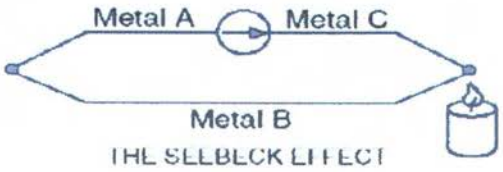
Pada tugas ini menggunakan sensor thermocouple. Thermocouple merupakan sensor suhu yang bekerja berdasarkan perubahan temperatur pada masing-masing ujung kedua bahan penyusunnya, yang mengakibatkan timbulnya beda potensial pada bahan penyusunnya. Thermocouple terbuat dari dua kawat logam yang berbeda, pada masing-masing ujung dilas menjadi satu. Perubahan temperatur pada thermocouple sebanding dengan perubahan besarnya emf yang timbul, dan dengan penampang kawatnya bila suhu pada reference junction (ujung yang bersuhu lebih rendah atau dingin) diketahui dan emf yang timbul dapat diukur maka dapat diketahui suhu pada hot junction.

Thermocouple bekerja berdasarkan timbulnya energy listrik saat konduktor (contohnya : besi) didekatkan dengan panas. Pengukuran temperatur dilakukan dengan menghitung beda voltase dari masing-masing kaki konduktor. Salah satu kaki berperan sebagai kaki "panas" dan kaki yang lain berperan sebagai kaki "dingin". Saat kaki panas menghasilkan energy listrik, konduktor tambahan (kaki "dingin") juga akan merasakan panas dan menghasilkan energy listrik sendiri untuk melawan energy listrik dari kaki "panas". Efek tergantung dari besi yang digunakan. Menggunakan besi yang berbeda untuk menyelesaikan sirkuit akan menghasilkan sirkuit dengan kedua

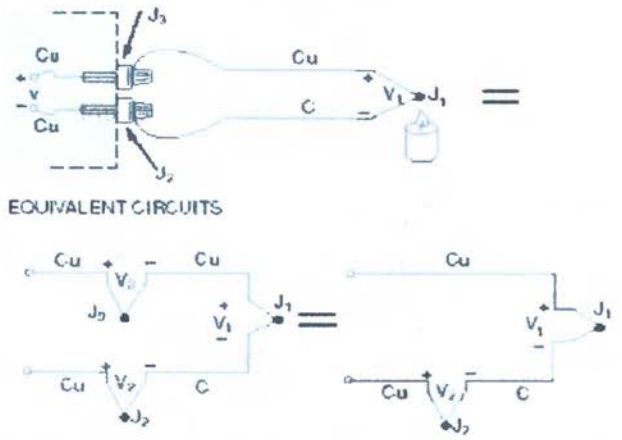
kaki yang menghasilkan voltase berbeda, menyisakan selisih voltase yang digunakan dalam pengukuran. Thermocouple mengukur perbedaan temperature diantara kedua kaki, bukan temperatur absolute.

- **Prinsip kerja thermocouple**

Jika dua buah kabel yang terbuat dari logam yang berbeda disambungkan pada kedua ujungnya dan salah satu ujung sambungan itu dipanaskan, akan mengalir arus.

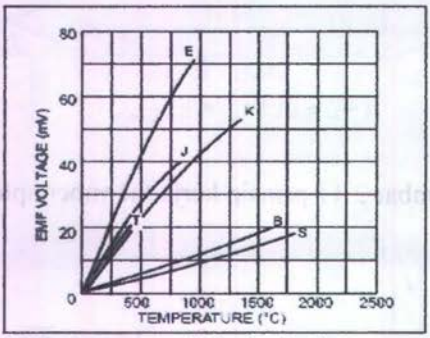


Gambar 2.11 prinsip kerja thermocouple



Gambar 2.12 mengukur tegangan pada thermocouple

Gambar 2.13 Sensor thermocouple



Grafik 2.2 Respon jenis-jenis thermocouple

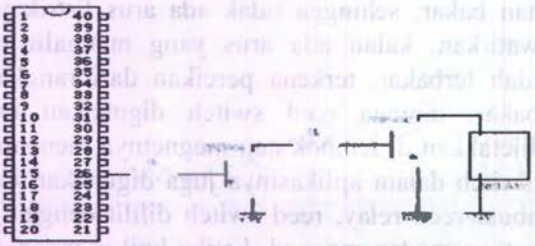
2.8 Sensor Reed Swicth

Reed sensor digunakan untuk mendeteksi adanya medanmegned, reed switch adalah suatu komponen elektronika yang sangat sederhana dengan menggunakan dua buah kawat untuk saling menghubungkan. keuntungan dengan menggunakan reed switch adalah ujung kontaktor telah terindungi dengan aman dari lingkungan luar.reed switch digunakan untuk mendeteksi medan megned, reed swith mempunyai default normaly open, tetapi saat didekatkan pada magned, maka akan close. reed switch biasanya menggunakan magnet untuk membuka atau menutup cirkuit. sebagai contoh: Reed switch digunakan untuk sensor alarm, atau kontek magnetik yang diletakkan di daerah yang

mengandung bahan bakar, sehingga tidak ada arus listrik yang mengalir, dikhawatirkan, kalau ada arus yang mengalir pada daerah yang mudah terbakar, terkena percikan dari rangkaian, maka akan terbakar. dimana reed switch digunakan untuk pemancar yang diletakkan di tembok dan megnetnya mengapung diatas air. Reed switch dalam aplikasinya juga digunakan untuk relay untuk membuat reed relay, reed switch dililit dengan koil sehingga mendapatkan medan magned. ketika koil mendapatkan suatu energi, maka akan menyebabkan cirkuit tertutup. Reed dibentuk dengan beberapa bagian diantara lapisan ruthenium, diisi gas lebam, tanpa tekanan yang kering reed switch dengan plat timah mengarah keluar, untuk saklar dengan daya antara 100 microwatt dan 120 watt. reed switch dapat digunakan di berbagai macam pengaplikasianya, dari sinyal switch dengan tingkatan yang rendah untuk handphone. sampai temperatur alat-alat pemanas. Reed switch didesain khusus untuk saklar bermuatan rendah dan menengah tanpa mengorbankan ukuranya, reed switch memiliki konfigurasi yang tinggi dengan berbeda-beda respek. standart ukuran besar reed switch disesuaikan berdasarkan spesifikasinya seperti induktif , lampu filamen dan tegangan garis. Keuntungan dari reed switch adalah memiliki umur yang lebih panjang dengan arus yang kecilini dapat dibuktikan dengan melalui ribuan test. meskipun telah lama tidak digunakan. Bentuk reed switch adalah potential divider daimana tegangan output yang ditentukan oleh upper dan lower pada rangkaian. rangkaian untuk sensor reed switch tergantung pada sensor yang dihubungkan ke sensor unit atau inverted sensor, saat terhubung ke sensor unit.

2.9 Driver Relay

Driver relay ini digunakan untuk menghubungkan pin mikrokontroller sebagai controller dengan *hardware* luar berupa pengaktifan *relay*. *Driver relay* ini yang nantinya sebagai akan menyalakan atau memtikan pompa air dan solenoid valve sesuai dengan perintah yang diberikan oleh controller.



Gambar 2.14 Driver Relay

2.9 Thermocontrol

Thermocontrol adalah suatu komponen yang dimana fungsinya sebagai kontak arus listrik. Yang dimana untuk mengontrol temperatur heater pada mesin daur ulang plastik agar sesuai dengan setpoint.

Thermocontrol disini bergerak untuk memberi dan memutus arus listrik kedalam heater. Ketika temperatur telah sesuai denga setpoint maka arus listrik yang masuk kedalam heater akan diputus agar temperatur heater tetap pada setpoint.

BAB III
PERANCANGAN DAN PEMBUATAN ALAT

3.1 Blok Diagram Perancangan Alat

Pada Bab III akan dijelaskan perancangan system pelet plastic *miniplant mesin peleleh* , baik berupa *software* dan *hardware*. Untuk perancangan *hardware* terdiri perancangan suplai daya, *Mikrokontroller* dan mesin srew extruder. Untuk aplikasi *software* digunakan bahasa pemrograman *code vision AVR*. Secara lebih jelas tahapan-tahapan yang ditempuh dalam pengerjaan tugas akhir.

Gambar 3.1 Blok sistem pengukuran data

3.2 Perancangan mesin pelet plastik

Untuk perancangan perangkat keras ini dimulai dari perancangan dan pembuatan wiring yang dimulai dari instalasi sumber tegangan PLN ke relay, heater, trafo, dan motor. Sensor suhu thermocouple dan opthocoupler. rangkaian mikrokontroller, dan driver relay pada motor dan heater mesin pencacah plastic.

3.2.1 Perancangan Catu Daya

Catu daya (*power supply)* merupakan sumber tenaga yang dibutuhkan suatu rangkaian elektronika untuk bekerja. Besar *power supply* ini tergantung oleh spesifikasi dari alat masing – masing. Pada perancangan elektrik miniplant daur ulang plastik ini *power supply* digunakan untuk *mensupply* rangkaian *minimum system*, rangkaian sensor dan driver relay

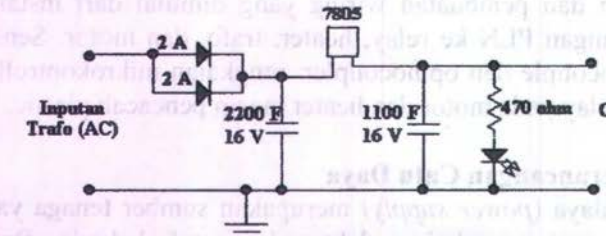
Pada rangkaian *power supply* pada umumnya kita sering menggunakan IC regulator dalam mengontrol tegangan yang kita inginkan. Regulator tegangan menjadi sangat penting gunanya

apabila kita mengaplikasikan *system power* tersebut untuk rangkaian – rangkaian yang membutuhkan tegangan yang sangat stabil. Misalkan untuk sistem *digital*, terutama untuk *Minimum system* (Mikroprosesor atau Mikrokontroler) yang sangat membutuhkan tegangan dan arus yang sangat stabil.

IC regulator yang umum digunakan untuk, mengontrol tegangan adalah IC keluarga 78XX. IC ini dapat mengontrol tegangan dengan baik. Keluaran tegangan yang diinginkan tinggal melihat tipe yang ada. Misalkan tipe 7805 dapat memberikan keluaran tegangan 5 Volt dengan toleransi ±1, dengan arus keluaran maksimal 1500 mA.

- **Rangkaian Tegangan 5 Volt**

Rangkaian ini merupakan aplikasi dari regulator tegangan IC 7805, yang dapat mengeluarkan tegangan 5 Volt Dc. Rangkaian ini dibangun dari beberapa komponen yakni, dioda 1N 4002 yang merupakan dioda yang dapat melewatkan arus maksimal 2 *Ampere*, selain itu dioda ini juga berfungsi untuk menjadikan sinyal AC sinusoidal yang melewatinya menjadi sinyal DC setengah gelombang.



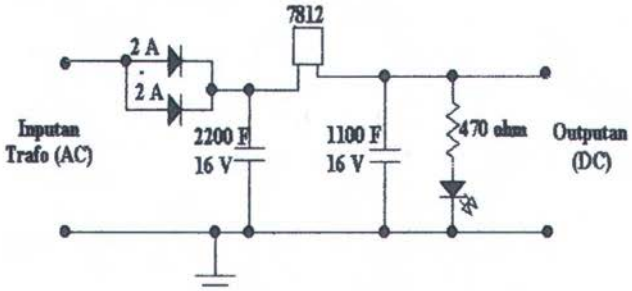
Gambar 3.2 Sistem Power 5 Volt

Kemudian selain itu dibangun oleh kapasitor yang berfungsi untuk memperhalus sinyal DC keluaran dari dioda. Setelah itu sinyal DC keluaran dari kapasitor akan di inputkan pada regulator 7805. Hasil keluaran dari IC 7805 adalah tegangan 5 Volt dengan arus 1,5 A. Rangkaian ini nantinya akan digunakan

untuk memberikan tegangan untuk rangkaian *minimum system* mikrokontroler.

- **Rangkaian Tegangan 12 Volt**

Rangkaian ini merupakan aplikasi dari regulator tegangan IC 7809, yang dapat mengeluarkan tegangan 12 Volt. Rangkaian ini dibangun dari beberapa komponen yakni, dioda 1N 4002 yang merupakan dioda yang dapat melewatkan arus maksimal 2 *Ampere*, selain itu dioda ini juga berfungsi untuk menjadikan sinyal AC sinusoidal yang melewatinya menjadi sinyal DC setengah gelombang.



Gambar 3.3 Sistem Power 12 Volt

Kemudian selain itu dibangun oleh kapasitor yang berfungsi untuk memperhalus sinyal DC keluaran dari dioda. Setelah itu sinyal DC keluaran dari kapasitor akan di inputkan pada regulator 78012. Hasil keluaran dari IC 78012 adalah tegangan 12 Volt dengan arus 2,5 A. Rangkaian ini nantinya akan digunakan untuk memberikan tegangan untuk driver relay.

3.2.2 Rangkaian Sensor *Reed Swicth*

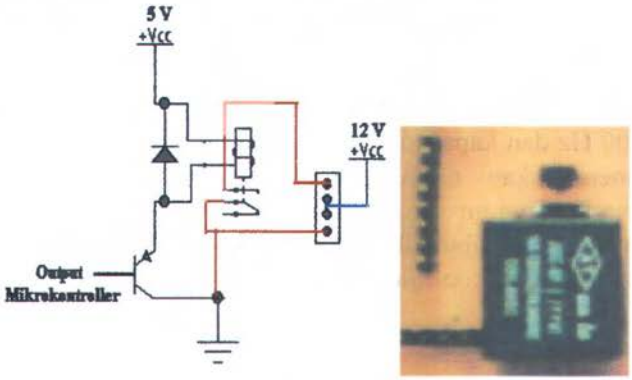
Rangkaian ini berfungsi sebagai pembaca putaran pada motor. Reed sensor digunakan untuk mendeteksi adanya medan magned, reed switch adalah suatu komponen elektronika yang sangat sederhana dengan menggunakan dua buah kawat untuk saling menghubungkan. keuntungan dengan menggunakan reed

switch adalah ujung kontaktor telah terindungi dengan aman dari lingkungan luar.reed switch digunakan untuk mendeteksi medan megned, reed swith mempunyai default normaly open, tetapi saat didekatkan pada magned, maka akan close. reed switch biasanya menggunakan magnet untuk membuka atau menutup cirkuit. sebagai contoh: Reed switch digunakan untuk sensor kecepatan motor. dimana reed switch digunakan untuk medeteksi setiap satu kali rotasi motor maka reed switch akan membuka tutup kontaktor dan akan memberika logika nol satu. Dari data itu dikalkulasi selama satu menit maka akan didapatkan percepatan RPM motor. Reed switch dalam aplikasinya juga digunakan untuk relay untuk membuat reed relay, reed switch dililit dengan koil sehingga mendapatkan medan magned. ketika koil mendapatkan suatu energi, maka akan menyebabkan cirkuit tertutup. Reed dibentuk dengan beberapa bagian diantara lapisan ruthenium, diisi gas lebam, tanpa tekanan yang kering reed switch dengan plat timah mengarah keluar, untuk saklar dengan daya antara 100 microwatt dan 120 watt. Reed switch didesain khusus untuk saklar bermuatan rendah dan menengah tanpa mengorbankan ukuranya, reed switch memiliki konfigurasi yang tinggi dengan berbeda-beda respek. standart ukuran besar reed switch disesuaikan berdasarkan spesifikasinya seperti induktif , lampu filamen dan tegangan garis. Keuntungan dari reed switch adalah memiliki umur yang lebih panjang dengan arus yang kecilini dapat dibuktikan dengan melalui ribuan test. meskipun telah lama tidak digunakan. Bentuk reed switch adalah potential divider daimana tegangan output yang ditentukan oleh upper dan lower pada rangkaian. rangkaian untuk sensor reed switch tergantung pada sensor yang dihubungkan ke sensor unit atau inverted sensor, saat terhubung ke sensor unit.

3.2.3 Rangkaian Driver Relay

Fungsi utama dari *driver relay* ini adalah sebagai pengaktif *relay*, yang kemudian *relay* tersebut mengaktifkan *device* selanjutnya. Pada *driver relay* ini digunakan transistor

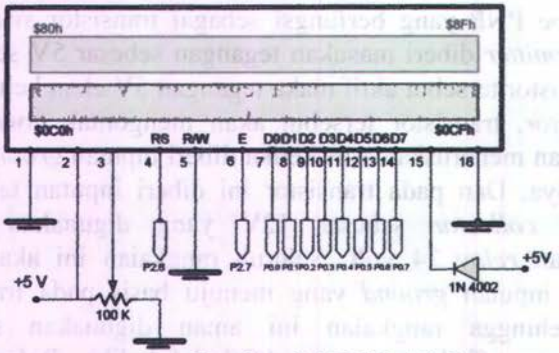
2N3906 *type* PNP yang berfungsi sebagai transistor *switching*, pada kaki *emitter* diberi masukan tegangan sebesar 5V sehingga ketika transistor tersebut aktif maka tegangan 5V akan keluar dari kaki *collector*, transistor tersebut akan mengontak (*switching*) atau aktif dan meneruskan arus ketika diberi inputan *ground* pada kaki basisnya. Dan pada transistor ini diberi inputan tegangan pada kaki *collector* sebesar 12V yang digunakan untuk mengaktifkan *relay* 24 volt. Seluruh rangkaian ini akan aktif ketika ada inputan *ground* yang menuju basis pada transistor 2N3906 sehingga rangkaian ini aman digunakan sebagai pengendali *on-off* dengan arus AC(bolak-balik). Relay yang diaktifkan digunakan untuk mengendalikan heater.



Gambar 3.6 *Driver relay*

3.2.4 Perancangan LCD

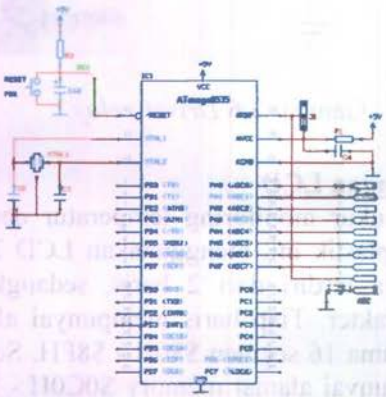
Pada alat ukur monitoring temperatur dan Rpm motor pada mesin pelet plastik ini, menggunakan LCD 2x16 karakter. Artinya segmennya terdiri dari 2 baris, sedangkan tiap baris terdiri dari 16 karakter. Tiap baris mempunyai alamat memory sendiri. Baris pertama 16 segmen $80H - $8FH. Sedangkan pada baris kedua mempunyai alamat memory $0C0H - $0CFH. Pin – pin konfigurasinya dapat dilihat pada gambar 3.9



Gambar 3.7 LCD 16x2

3.2.5 Perancangan Mikrokontroler ATmega8535L

Mikrokontroler ATmega8535L memiliki 4 buah port I/O yaitu *port* A, *port* B, *port* C dan *port* D. Pada *port* A terdapat program ADC yang dapat diatur jumlah bitnya yaitu 8 bit dan 10 bit. Pada kaki XTAL 1 dan XTAL 2 dirangkai dengan kristal 11,052900 Hz dan kapasitor 30 pF. Rangkaian tersebut berfungsi untuk memberikan clock pada mikrokontroler agar dapat memproses program dengan baik. Pada mikrokontroler ATmega8535L membutuhkan sumber tegangan 5V DC untuk mengaktifkan mikrokontroler itu sendiri.



Gambar 3.8 Rangkaian minimum sistem ATmega8535

3.2.5 Thermocouple

Thermocouple disini digunakan untuk mengukur suhu pada mesin pelet. Thermocouple yang digunakan disini adalah thermocouple jenis K. Thermocouple jenis K ini memiliki range pengukuran antara -200°C sampai dengan +1200°C. Karena suhu yang diukur cukup tinggi yaitu 0 °C sampai dengan 160 °C. Thermocouple jenis K ini memiliki sensitivitas 41uV/°C.

Gambar 3.9 Sensor suhu Thermocouple

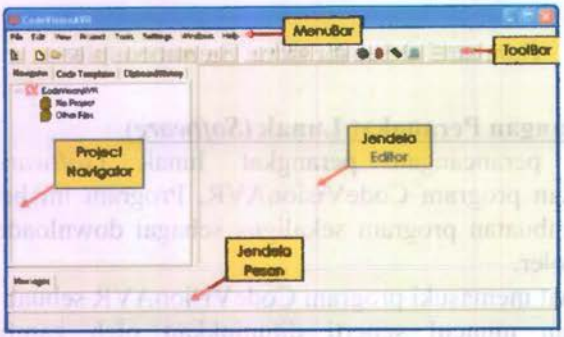
3.3 Perancangan Perangkat Lunak (*Software*)

Untuk perancangan perangkat lunak (*software*) ini menggunakan program CodeVisionAVR. Program ini berfungsi sebagai pembuatan program sekaligus sebagai downloader pada mikrokontroler.

Pada saat memasuki program CodeVisionAVR sebuah *Splash Screen* akan muncul seperti ditunjukkan oleh gambar 3.4 Informasi tentang versi yang dipakai dan keterangan *evaluation* akan terlihat.

Gambar 3.4 Splash Screen CodeVisionAVR

Kemudian IDE dari CodeVisionAVR akan muncul seperti yang ditunjukkan oleh Gambar 3.5



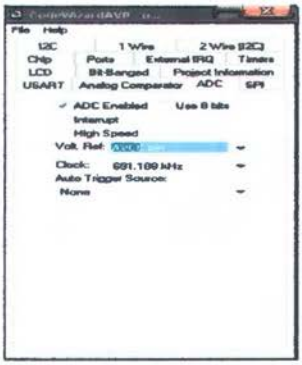
Gambar 3.5 IDE CodeVisionAVR

Setelah IDE CodeVisionAVR muncul, mulai mengatur mulai dari *chip*, *port*, ADC dan LCD. Pada pengaturan chip diatur menggunakan mikrokontrler ATmega8535 dan menggunakan kristal 11,052900 Hz.

Gambar 3.6 Tab Chip

Setalah mengatur tab chip, selanjutnya mengatur tab LCD. Pada tab LCd ini menentukan letak port yang akan dihubungkan dengan LCD. Pada minimum sistem mikrokontroler yang digunakan LCD diletakkan pada port C dengan menggunakan LCD tipe 16x2.

Selain tab LCD tab yang diatur yaitu tab *ports* dan tab ADC. Pada minimum sistem mikrokontroler port yang digunakan yaitu port A.0 dan port A.1. Pada setiap port pengaturan resistor pull up diatur pada toggle state. Sedangkan pada tab ADC menggunakan ADC 10 bit dan tegangan refrensinya menggunakan pin AVCC.



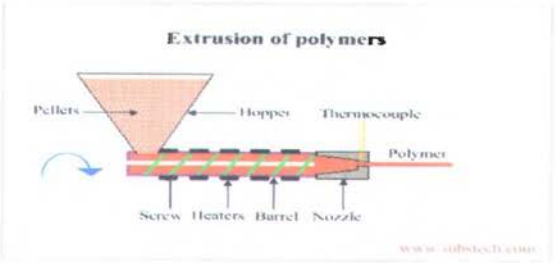
Gambar 3.7 Tab ADC

Setelah semua diatur dengan otomatis telah terprogram penempatan port, LCD, ADC dan chip.

Gambar 3.8 Program mikrokontroler ATmega8535

Alur Komunikasi data adalah sebagai berikut :

Gambar 3.9 flowchat alur komunikasi data



Gambar 3.10 proses extrusion plastik

BAB IV
PENGUJIAN DAN ANALISA DATA

Pada bab IV akan dibahas mengenai pengujian dan kalibrasi terhadap hardware yaitu pengujian statis dan pengujian dinamis. Untuk pengujian statis meliputi pengujian terhadap sensor thermocouple dan sensor reed swicth. Setelah itu akan dilanjutkan dengan pengujian dinamik terhadap sistem untuk mendapatkan parameter kontrol kestabilan.

Setelah melakukan pengujian statis dan pengujian dinamis akan didapatkan data pengukuran dan parameter kontrol kestabilan. Untuk mengetahui baik tidaknya kerja alat maka akan dilakukan kalibrasi *hardware.*

Mekanisme kerja sistem pada alat system monitoring temperatur dan Rpm motor mesin pelet plastik berbasis Mikrokontroller ATMega 8535, adalah didasarkan pada pengukuran sensor suhu *Thermocouple dan reed swicth* Keluaran dari sensor berupa tegangan yang masuk ke ADC pada port A mikrokontroller. Setelah data masuk ke mikrokontroller maka hasil pengukuran tersebut akan di displaykan ke LCD berupa pengukuran digital. Sedangkan sensor *Bimetal* memberikan display analog monitoring temperatur. Sistem pembuatan progresif kerja digambarkan desain algoritma dibawah ini:

- Instalasi sensor, komponen *hardware*, memulai adanya akusisi data.
- Kemudian sensor Bimetal dikoneksikan ke srew extruder sebagai alat pengukur temperatur.
- Kemudian sensor reed swicth dikoneksikan ke motor sebagai alat pengukur RPM.
- ADC mengkonversi data sinyal analog pengukuran menjadi data sinyal digital 0 – 255 bit
- Mikrokontroller membaca sinyal ADC 0-255 untuk dimasukkan ke LCD.
- LCD menampilkan hasil pengukuran .

4.1 Analisa Data

4.1.1 Pengukuran Hardware

- **Pengukuran Sensor Reed Swicth**

Sensor rotasi (percepatan motor) yang digunakan pada mesin extruder ini adalah *reed swicth*. Pengujian pada rangkaian sensor adalah mengukur tegangan keluaran dari *Reed Swicth* langsung masuk ke rangkaian ADC yang terdapat pada Port A mikrokontroller.

Tabel 4.1 Hasil pengukuran sensor dengan stroboscope tachometer digital sebagai kalibrator

No	Reed Swicth (rpm)	tegangan keluaran (volt)
1	2900	4,57
2	2940	4,63
3	2925	4,60
4	2915	4,58
5	2930	4,61

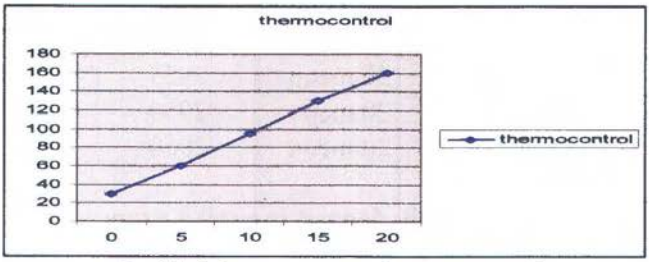
4.1.2 Pengujian Sensor suhu Thermocouple

Pengujian *sensor* dilakukan untuk mengetahui sensitifitas dari *sensor*. Pengujian dilakukan dengan memasukkan *sensor* pada srew extruder, untuk mengaktifkan *sensor* maka perlu mengunakan thermocontrol, Nilai keluaran dari *sensor thermocouple* berupa tegangan yang nantinya diolah didalam thermocontrol dan di*display*kan pada sensor bimetal secara analog. Pengujian dilakukan untuk memonitoring temperatur dengan *range* 30-190°C pada proses pelelehan plastik dan untuk mengendilkan temperatur agar temperatur tetap konstan sesuai dengan set point yaitu 30 °C-190 °C. Pengambilan data dilakukan 5 kali, masing-masing sebanyak 5 data. Berikut adalah data yang diperoleh dari pengukuran sensor Thermocouple dan sensor bimetal. Bimetal ini digunakan sebagai pembanding dan display

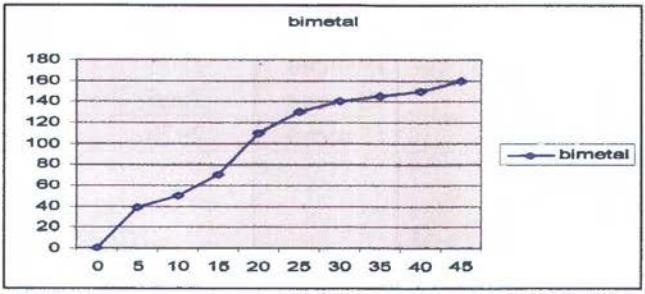
analog sehingga dapat diketahui peribahan temperatur pada srew extruder :

Tabel 4.2 Data uji Pengukuran Thermocontrol dan *sensor* Bimetal.

Thermocouple	t	Bimetal	t
SP = 160 °C	20 menit	39	5 Menit
		50	10 Menit
30	0	70	15 Menit
60	5	110	20 Menit
95	10	130	25 Menit
130	15	140	30 Menit
160	20	145	35 Menit
		150	40 Menit
		160	45 Menit



Grafik 4.1 temperatur thermocontrol



Grafik 4.2 temperatur bimetal

4.3 Pengujian Proses material plastik.

4.3.1 proses pelelehan plastik

Tabel 4.3 pelelehan plastik dengan input 0,6 gram

Input (gram)	T	t	Rpm	Output (gram)
0.6	190 °C	20 menit	2940	0,4
0.6	190 °C	21 menit	2935	0,5
0.6	190 °C	20 menit	2930	0,4
0.6	190 °C	20 menit	2930	0,4
0.6	190 °C	21 menit	2935	0,5

Tabel 4.4 pelelehan plastik dengan input 0,5 gram

Input (gram)	T	t	Rpm	Output (gram)
0,5	190 °C	20 menit	2960	0,4
0.5	190 °C	19 menit	2955	0,3
0.5	190 °C	20 menit	2955	0,3
0.5	190 °C	20 menit	2950	0,4
0.5	190 °C	20 menit	2950	0,3

Tabel 4.5 pelelehan plastik dengan input 0,4 gram

Input (gram)	T	t	Rpm	Output (gram)
0.4	190 °C	19 menit	2970	0,3
0.4	190 °C	19 menit	2965	0,3
0.4	190 °C	19 menit	2975	0,3
0.4	190 °C	18 menit	2965	0,2
0.4	190 °C	17 menit	2970	0,3

Tabel 4.6 pelelehan plastik dengan input 0,3 gram

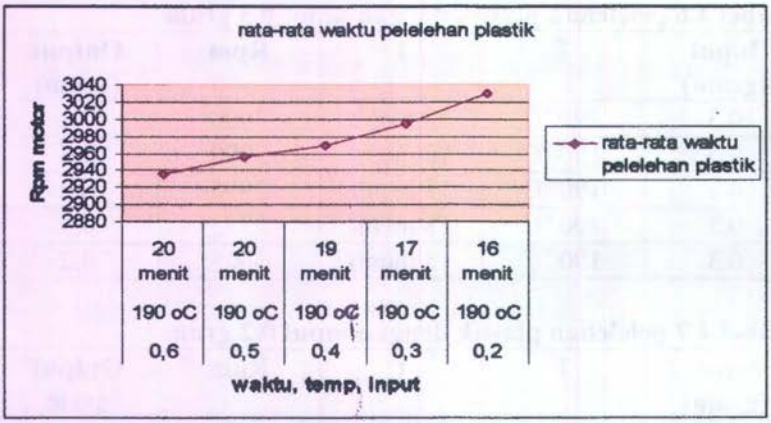
Input (gram)	T	t	Rpm	Output (gram)
0.3	190 °C	17 menit	3000	0,2
0.3	190 °C	18 menit	2990	0,3
0.3	190 °C	17 menit	2995	0,2
0.3	190 °C	18 menit	2985	0,3
0.3	190 °C	17 menit	3005	0,2

Tabel 4.7 pelelehan plastik dengan input 0,2 gram

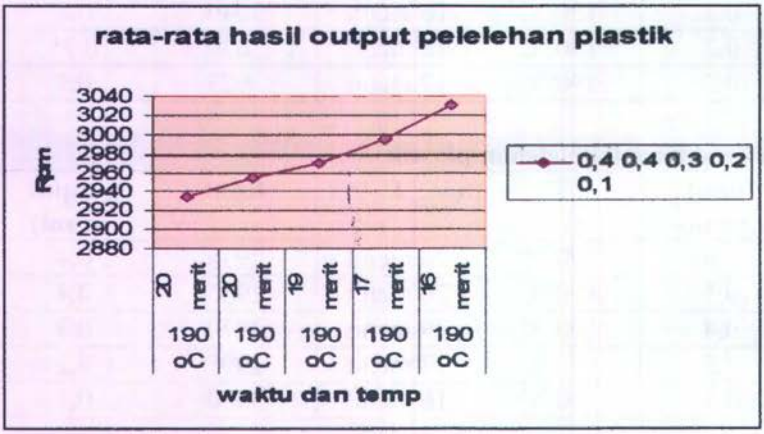
Input (gram)	T	t	Rpm	Output (gram)
0.2	190 °C	17 menit	3040	0,1
0.2	190 °C	16 menit	3020	0,1
0.2	190 °C	16 menit	3040	0,1
0.2	190 °C	16 menit	3030	0,75
0.2	190 °C	17 menit	3025	0,1

Tabel 4.8 hasil pelelehan plastik

Input (gram)	T	t	Rpm	Output (gram)
0,6	190 °C	20 menit	2935	0,4
0,5	190 °C	20 menit	2955	0,4
0,4	190 °C	19 menit	2970	0,3
0,3	190 °C	17 menit	2995	0,2
0,2	190 °C	16 menit	3030	0,1



Grafik 4.3 rata-rata hasil pelelehan plastik



Grafik 4.4 rata-rata hasil output pelelehan plastik

4.4 Data Informasi

Pada alat monitoring temperatur dan rpm motor pada alat daur ulang plastik ini terdapat induksi pada heater, dikarenakan kondisi heater yang begitu besar wattnya, yaitu 900 watt dan letak daripada heater yang saling berhimpitan menyebabkan induksi pada komponen heater. Pada motor juga begitu yaitu kurangnya

daya sehingga bila digunakan dalam proses agak banyak maka motor tidak mau berputar. Dikarenakan load pada srew yang terlalu berat dan ditambah pula oleh beban input material plastik yang pekat apabila leleh pada srew.

4.4 Analisa dan Pembahasan

Pada tugas akhir ini membahas tentang monitoring temperarur proses daur ulang plastik. Plastik yang dilelehkan pada proses pelet dimonitoring temperaturnya dengan sensor thermocouple dan bimetal agar dapat proses sesuai dengan set point. Dan menggunakan motor untuk mendorong material plastik supaya dapat mendorong output material plastik. Data dari sensor termokopel diolah di dalam thermocontrol, jika suhu belum sesuai dengan set point maka pada thermocontrol tidak akan menghidupkan heater. Data yang telah diperoleh maka akan ditampilkan pada sensor bimetal.

Pengambilan data pada tugas akhir ini dilakukan sebanyak 5 kali, dengan set point 160^0C. Pengambilan data dilakukan setiap 5 menit, data diambil dari pengukuran sensor bimetal dan langsung didisplaykan secara analog. Bimetal ini digunakan sebagai kalibrator / pembanding. Dilihat dari data yang didapatkan sensor thermocouple lebih sensitif bila dibandingkan dengan bimetal.

Dari data yang diperoleh pada RPM motor secara kontinu maka hasil dari proses yang didapatkan akan secara kontinu juga karena kecepatan dorongan meterial plastik secara konstan.

BAB V
KESIMPULAN DAN SARAN

5.1 Kesimpulan

Berdasarkan pengujian hasil data dan analisa data dari system monitoring temperature dan kecepatan motor (Rpm) pada mini plan mesin pellet plastic. maka dapat disimpulkan sebagai berikut :

- Penggunaan LCD sebagai sistem monitoring Rpm dari kerja mesin daur ulang secara *real time* bekerja sesuai keadaan sebenarnya. Hal ini akan menambah keunggulan dari mikrokontroller sebagai monitoring, sehingga waktu perbaikan menjadi semakin cepat.
- Pada sensor reed swicth didapatkan data linier pada 2940 RPM kecepaan konstan.
- Dari data thermocouple yang diambil untuk mencapai suhu 190°C-200°C titik leleh plastik tidak cair.
- Pada proses pelelehan plastik tidak bisa banyak, diperlukan waktu agak lama karena dimensi kapasitas sistem 0,6 s/d 0,1 gram/ 16 s/d 20 menit.
- Keuntungan sistem monitoring secara *real time* pada operator antara lain tidak memerlukan banyak operator dan kerja operator menjadi lebih ringan.
- Program visual yang dibuat dengan menggunakan *LCD* untuk pengamatan mesin daur ulang dapat bekerja sesuai dengan status peralatan saat bekerja.

5.2 Saran

- Menambahkan pemakaian kontrol *manual* pada tampilan visual agar panel kontrol menjadi lebih lengkap.
- Menambahkan program sistem jaringan (*networking*), misalnya menggunakan modem agar dapat diakses lewat internet.

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LAMPIRAN A
DATA SPESIFIKASI ALAT

1. **Heater**
   - Jenis turbular heater
   - Daya 900 watt
   - Max. temp 300 °C
2. **Motor**
   - Jenis Motor 1 fasa
   - Daya 100 watt
   - Max. Rpm 2980
3. **Sensor Thermocouple**
   - Temp. Range -200 to 1260 °C
   - Seebeck Coefficient 40 mV/°C
4. **Thermokontrol**
   - Temp. range 0 to 200 °C

LAMPIRAN B
INSTRUKSI MANUAL

HARDWARE

1. Berikan supply input tegangan 220 Volt AC (PLN) pada unit *Power Supply* melalui kabel yang terhubung pada Local Panel.
2. Berikan *supply input* tegangan pada rangkaian *Mikrokontroller.*
3. Pada sensor, hubungkan kabel yang ada pada sensor ke *port* input Mikrokontroller AVR ATMega8535 di *hardware*.
4. *Hardware* siap untuk dioperasikan.

SOFTWARE

1. Hubungkan kabel com Local Panel yang sudah terpasang dengan port DB9 ke port serial yang terdapat pada PC.
2. Run program Visual Basic 6.0 dengan menekan menu Start, All Program, Microsoft Visual Basic 6.0.
3. Open project Monitoring Simulator Proses Multivariable, kemudian run project.
4. Klik panel Start pada control.
5. Software siap dioperasikan.

LAMPIRAN C
LISTING PROGRAM

```
/*****************************************************
*
This program was produced by the
CodeWizardAVR V1.25.3 Standard
Automatic Program Generator
© Copyright 1998-2007 Pavel Haiduc, HP InfoTech s.r.l.
http://www.hpinfotech.com

Project :
Version :
Date    : 1/10/2009
Author  : F4CG
Company : F4CG
Comments:


Chip type           : ATmega8535L
Program type        : Application
Clock frequency     : 11.059200 MHz
Memory model        : Small
External SRAM size  : 0
Data Stack size     : 128
*****************************************************
/

#include <mega8535.h>
#include <delay.h>
#include <stdio.h>


// Alphanumeric LCD Module functions
```

```
#asm
  .equ __lcd_port=0x15 ;PORTC
#endasm
#include <lcd.h>

unsigned int count=0,temp0,rps;
char buffer_lcd[33];
unsigned long sec;

// External Interrupt 0 service routine
interrupt [EXT_INT0] void ext_int0_isr(void)
{
// Place your code here
count++;

}

// Timer 1 overflow interrupt service routine
interrupt [TIM1_OVF] void timer1_ovf_isr(void)
{
// Place your code here
// Place your code here
// Place your code here
TCNT1H=0xC2;
TCNT1L=0xF7;
sec++;
if (sec==3)
{
        sec=0;
        rps=(count*60)/3.7;
        count=0;
};
}

#define ADC_VREF_TYPE 0x40
```

```
// Read the AD conversion result
unsigned int read_adc(unsigned char adc_input)
{
ADMUX=adc_input | (ADC_VREF_TYPE & 0xff);
// Start the AD conversion
ADCSRA|=0x40;
// Wait for the AD conversion to complete
while ((ADCSRA & 0x10)==0);
ADCSRA|=0x10;
return ADCW;
}

// Declare your global variables here

void main(void)
{
// Declare your local variables here

// Input/Output Ports initialization
// Port A initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In
Func2=In Func1=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T
State1=T State0=T
PORTA=0x00;
DDRA=0x00;

// Port B initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In
Func2=In Func1=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T
State1=T State0=T
PORTB=0x00;
DDRB=0x00;
```

```
// Port C initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In
Func2=In Func1=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T
State1=T State0=T
PORTC=0x00;
DDRC=0x00;

// Port D initialization
// Func7=In Func6=In Func5=In Func4=In Func3=In
Func2=In Func1=In Func0=In
// State7=T State6=T State5=T State4=T State3=T State2=T
State1=T State0=T
PORTD=0x00;
DDRD=0x00;

// Timer/Counter 0 initialization
// Clock source: System Clock
// Clock value: Timer 0 Stopped
// Mode: Normal top=FFh
// OC0 output: Disconnected
TCCR0=0x00;
TCNT0=0x00;
OCR0=0x00;

// Timer/Counter 1 initialization
// Clock source: System Clock
// Clock value: kHz
// Mode: Normal top=FFFFh
// OC1A output: Discon.
// OC1B output: Discon.
// Noise Canceler: Off
// Input Capture on Falling Edge
TCCR1A=0x00;
```

```
TCCR1B=0x04;
TCNT1H=0xC2;
TCNT1L=0xF7;
OCR1AH=0x00;
OCR1AL=0x00;
OCR1BH=0x00;
OCR1BL=0x00;

// Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x04;

// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by Timer/Counter 1:
Off
// Analog Comparator Output: Off
ACSR=0x80;
SFIOR=0x00;

// Timer/Counter 2 initialization
// Clock source: System Clock
// Clock value: Timer 2 Stopped
// Mode: Normal top=FFh
// OC2 output: Disconnected
ASSR=0x00;
TCCR2=0x00;
TCNT2=0x00;
OCR2=0x00;

// External Interrupt(s) initialization
// INT0: On
// INT0 Mode: Falling Edge
// INT1: Off
// INT2: Off
GICR|=0x40;
```

```
MCUCR=0x02;
MCUCSR=0x00;
GIFR=0x40;

// Timer(s)/Counter(s) Interrupt(s) initialization
TIMSK=0x04;

// Analog Comparator initialization
// Analog Comparator: Off
// Analog Comparator Input Capture by Timer/Counter 1:
Off
ACSR=0x80;
SFIOR=0x00;

// ADC initialization
// ADC Clock frequency: 691.200 kHz
// ADC Voltage Reference: AVCC pin
// ADC High Speed Mode: Off
// ADC Auto Trigger Source: None
ADMUX=ADC_VREF_TYPE & 0xff;
ADCSRA=0x84;
SFIOR&=0xEF;

// LCD module initialization
lcd_init(16);

// Global enable interrupts
#asm("sei")

// LCD module initialization
lcd_init(16);
lcd_gotoxy(0,0);
lcd_putsf("Helmy Prasetya.");
lcd_gotoxy(0,1);
lcd_putsf("[24.06.030.034]");
```

```
delay_ms(2000);
count=0;

while (1)
    {
    // Place your code here
 // Place your code here
      lcd_gotoxy(0,1);
      sprintf(buffer_lcd,"Kec motor:%i rpm",rps);
      lcd_puts(buffer_lcd);
   // Place your code here
      delay_ms(100);
      lcd_clear();
    };
}
```

LAMPIRAN C

Features

- High-performance, Low-power AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 130 Powerful Instructions – Most Single Clock Cycle Execution
  - 32 x 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16 MHz
  - On-chip 2-cycle Multiplier
- Nonvolatile Program and Data Memories
  - 8K Bytes of In-System Self-Programmable Flash
    Endurance: 10,000 Write/Erase Cycles
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - 512 Bytes EEPROM
    Endurance: 100,000 Write/Erase Cycles
  - 512 Bytes Internal SRAM
  - Programming Lock for Software Security
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
    8 Single-ended Channels
    7 Differential Channels for TQFP Package Only
    2 Differential Channels with Programmable Gain at 1x, 10x, or 200x for TQFP Package Only
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, 44-lead PLCC, and 44-pad QFN/MLF
- Operating Voltages
  - 2.7 - 5.5V for ATmega8535L
  - 4.5 - 5.5V for ATmega8535
- Speed Grades
  - 0 - 8 MHz for ATmega8535L
  - 0 - 16 MHz for ATmega8535

ATMEL

8-bit AVR® Microcontroller with 8K Bytes In-System Programmable Flash

ATmega8535
ATmega8535L

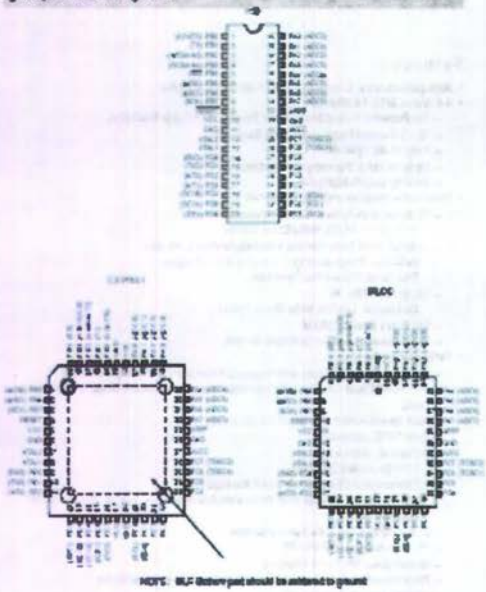
Summary

[illegible]

Note: This is a summary document. A complete document is available on our Web site at www.atmel.com.

Pin Configurations

Figure 1. Pinout ATmega8535



Disclaimer

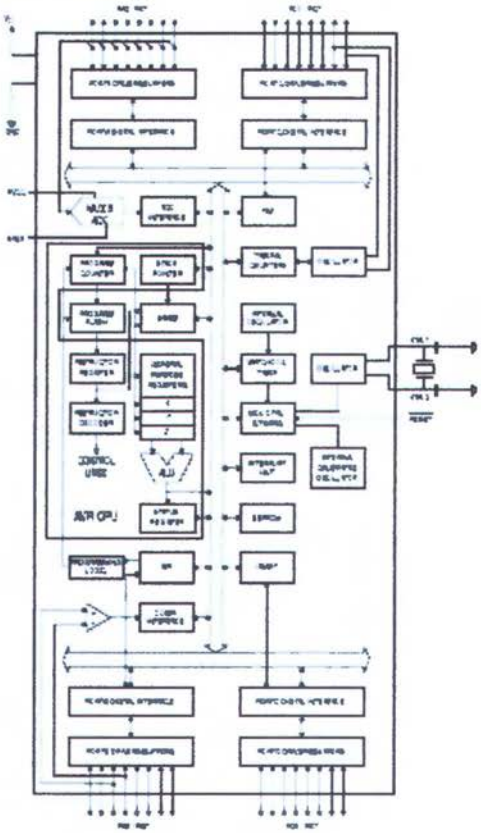
Typical values contained in this data sheet are based on simulations and characterization of other AVR microcontrollers manufactured on the same process technology. Min and Max values will be available after the device is characterized.

Overview

The ATmega8535 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing instructions in a single clock cycle, the ATmega8535 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed.

Block Diagram

Figure 2. Block Diagram



The AVR core combines a rich instruction set with 32 general purpose working registers. All 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers.

The ATmega8535 provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes EEPROM, 512 bytes SRAM, 32 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte-oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain in TQFP package, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the asynchronous timer continue to run.

The device is manufactured using Atmel's high density nonvolatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega8535 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control applications.

The ATmega8535 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, In-Circuit Emulators, and evaluation kits.

AT90S8535 Compatibility

The ATmega8535 provides all the features of the AT90S8535. In addition, several new features are added. The ATmega8535 is backward compatible with AT90S8535 in most cases. However, some incompatibilities between the two microcontrollers exist. To solve this problem, an AT90S8535 compatibility mode can be selected by programming the S8535C fuse. ATmega8535 is pin compatible with AT90S8535, and can replace the AT90S8535 on current Printed Circuit Boards. However, the location of fuse bits and the electrical characteristics differs between the two devices.

AT90S8535 Compatibility Mode

Programming the S8535C fuse will change the following functionality:

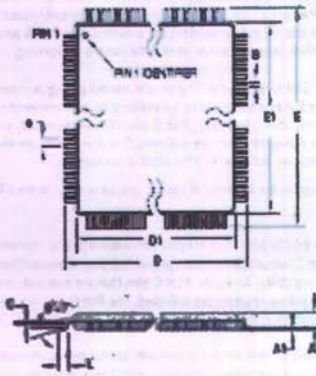
- The timed sequence for changing the Watchdog Time-out period is disabled. See "Timed Sequences for Changing the Configuration of the Watchdog Timer" on page 46 for details.
- The double buffering of the USART Receive Register is disabled. See "AVR USART vs. AVR UART – Compatibility" on page 146 for details.

Pin Descriptions

V_{CC}	Digital supply voltage.
GND	Ground.
Port A (PA7..PA0)	Port A serves as the analog inputs to the A/D Converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.
Port B (PB7..PB0)	Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port B also serves the functions of various special features of the ATmega8535 as listed on page 60.
Port C (PC7..PC0)	Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running.
Port D (PD7..PD0)	Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port D also serves the functions of various special features of the ATmega8535 as listed on page 64.
RESET	Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. The minimum pulse length is given in Table 15 on page 37. Shorter pulses are not guaranteed to generate a reset.
XTAL1	Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.
XTAL2	Output from the inverting Oscillator amplifier.
AVCC	AVCC is the supply voltage pin for Port A and the A/D Converter. It should be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} through a low-pass filter.
AREF	AREF is the analog reference pin for the A/D Converter.

Packaging Information

44A



COMMON DIMENSIONS
(Unit of Measure = mm)

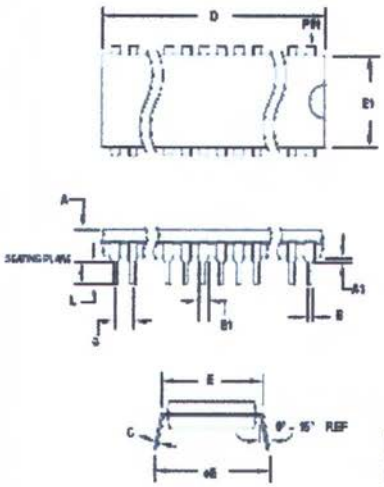
SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	1.20	
A1	0.05	–	0.15	
A2	0.95	1.00	1.05	
D	11.75	12.00	12.25	
D1	9.90	10.00	10.10	Note 2
E	11.75	12.00	12.25	
E1	9.90	10.00	10.10	Note 2
B	0.30	–	0.45	
C	0.09	–	0.20	
L	0.45	–	0.75	
e		0.80 TYP		

Notes:
1. This package conforms to JEDEC reference MS-026, Variation ACB.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.25 mm per side. Dimensions D1 and E1 are maximum plastic body size dimensions including mold mismatch.
3. Lead coplanarity is 0.10 mm maximum.

10/5/2001

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	44A, 44-lead, 10 x 10 mm Body Size, 1.0 mm Body Thickness, 0.8 mm Lead Pitch, Thin Profile Plastic Quad Flat Package (TQFP)	44A	B

40P6



COMMON DIMENSIONS

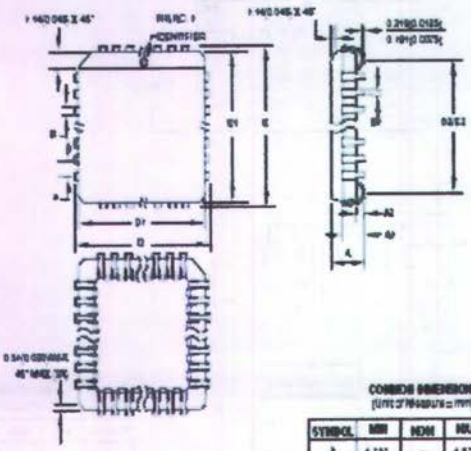
(Unit of measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A	–	–	4.826	
A1	0.381	–	–	
D	52.070	–	52.578	Note 2
E	15.240	–	15.875	
E1	13.462	–	13.970	Note 2
B	0.356	–	0.559	
B1	1.041	–	1.651	
L	3.048	–	3.556	
C	0.203	–	0.381	
eB	15.494	–	17.526	
e	2.540 TYP			

Notes: 1. This package conforms to JEDEC reference MS-011, Variation AC.
2. Dimensions D and E1 do not include mold Flash or Protrusion. Mold Flash or Protrusion shall not exceed 0.25 mm (0.010").

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	40P6, 40-lead (0.600"/15.24 mm Wide) Plastic Dual Inline Package (PDIP)	40P6	B

44J



COMMON DIMENSIONS
(Unit of Measure = mm)

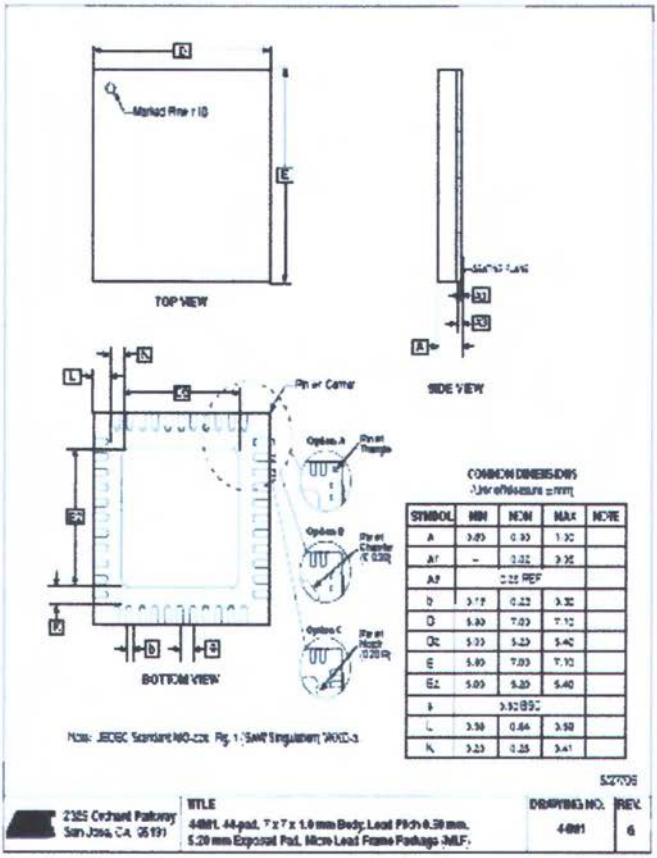
SYMBOL	MIN	NOM	MAX	NOTE
A	4.191	–	4.572	
A1	2.286	–	3.048	
A2	0.508	–	–	
D	17.399	–	17.653	
D1	16.510	–	16.662	Note 2
E	17.399	–	17.653	
E1	16.510	–	16.662	Note 2
D2/E2	14.859	–	16.002	
B	0.660	–	0.813	
B1	0.330	–	0.533	
e	1.270 TYP			

Notes:
1. This package conforms to JEDEC reference MS-018, Variation AC.
2. Dimensions D1 and E1 do not include mold protrusion. Allowable protrusion is 0.127 (0.254 mm) per side. Dimension D1 and E1 include mold mismatch and are measured at the extreme material condition at the upper or lower parting line.
3. Lead coplanarity is 0.004" (0.102 mm) maximum.

10/04/01

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	44J, 44-lead, Plastic J-leaded Chip Carrier (PLCC)	44J	B

44M1-A



COMMON DIMENSIONS

SYMBOL	MIN	NOM	MAX	NOTE
A	0.80	0.90	1.00	
A1	–	0.02	0.05	
A3		0.20 REF		
b	0.18	0.23	0.30	
D	6.90	7.00	7.10	
D2	5.05	5.20	5.40	
E	6.90	7.00	7.10	
E2	5.05	5.20	5.40	
e		0.50 BSC		
L	0.30	0.40	0.50	
K	0.20	0.25	0.41	

5/27/05

	TITLE	DRAWING NO.	REV.
2325 Orchard Parkway San Jose, CA 95131	44M1, 44-pad, 7 x 7 x 1.0 mm Body, Lead Pitch 0.50 mm, 5.20 mm Exposed Pad, Micro Lead Frame Package (MLF)	44M1	6

Datasheet Revision History

Please note that the referring page numbers in this section are referring to this document. The referring revision in this section are referring to the document revision.

Changes from Rev. 2502J-09/06 to Rev. 2502K-10/06

1. Updated TOP/BOTTOM description for all Timer/Counters Fast PWM mode.
2. Updated "Errata" on page 18.

Changes from Rev. 2502I-06/06 to Rev. 2502J-09/06

1. Updated "Ordering Information" on page 13.

Changes from Rev. 2502H-04/06 to Rev. 2502I-06/06

1. Updated code example "USART Initialization" on page 158.

Changes from Rev. 2502G-04/05 to Rev. 2502H-04/06

1. Added "Resources" on page 6.
2. Updated Table 7 on page 29, Table 17 on page 42 and Table 111 on page 258.
3. Updated "Serial Peripheral Interface – SPI" on page 136.
4. Updated note in "SR Rate Generator Unit" on page 180.

Changes from Rev. 2502F-06/04 to Rev. 2502G-04/05

1. Removed "Preliminary" and TBD's.
2. Updated Table 37 on page 69 and Table 113 on page 261.
3. Updated "Electrical Characteristics" on page 255.
4. Updated "Ordering Information" on page 13.

Changes from Rev. 2502E-12/03 to Rev. 2502G-06/04

1. MLF-package alternative changed to "Quad Flat No-Lead/Micro Lead Frame Package QFN/MLF".

Changes from Rev. 2502E-12/03 to Rev. 2502F-06/04

1. Updated "Reset Characteristics" on page 37.
2. Updated SPH in "Stack Pointer" on page 12.
3. Updated C code in "USART Initialization" on page 158.
4. Updated "Errata" on page 18.

Changes from Rev. 2502D-09/03 to Rev. 2502E-12/03

1. Updated "Calibrated Internal RC Oscillator" on page 29.
2. Added section "Errata" on page 18.

Changes from Rev. 2502C-04/03 to Rev. 2502D-09/03

1. Removed "Advance Information" and some TBD's from the datasheet.
2. Added note to "Pinout ATmega8535" on page 2.
3. Updated "Reset Characteristics" on page 37.
4. Updated "Absolute Maximum Ratings" and "DC Characteristics" in "Electrical Characteristics" on page 255.
5. Updated Table 111 on page 258.
6. Updated "ADC Characteristics" on page 263.
7. Updated "ATmega8535 Typical Characteristics" on page 264.
8. Removed CALL and JMP instructions from code examples and "Instruction Set Summary" on page 10.

Changes from Rev. 2502B-09/02 to Rev. 2502C-04/03

1. Updated "Packaging Information" on page 14.
2. Updated Figure 1 on page 2, Figure 84 on page 179, Figure 85 on page 185, Figure 87 on page 191, Figure 98 on page 207.
3. Added the section "EEPROM Write During Power-down Sleep Mode" on page 22.
4. Removed the references to the application notes "Multi-purpose Oscillator" and "32 kHz Crystal Oscillator", which do not exist.
5. Updated code examples on page 44.
6. Removed ADHSM bit.
7. Renamed Port D pin ICP to ICP1. See "Alternate Functions of Port D" on page 64.
8. Added information about PWM symmetry for Timer 0 on page 79 and Timer 2 on page 126.
9. Updated Table 64 on page 169, Table 75 on page 190, Table 76 on page 193, Table 77 on page 196, Table 100 on page 253, Table 113 on page 261.
10. Updated description on "Bit 5 – TWSTA: TWI START Condition Bit" on page 162.
11. Updated the description in "Filling the Temporary Buffer (Page Loading)" and "Performing a Page Write" on page 231.
12. Removed the section description in "SPI Serial Programming Characteristics" on page 254.
13. Updated "Electrical Characteristics" on page 255.

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Fax: (33) 4-76-58-34-80

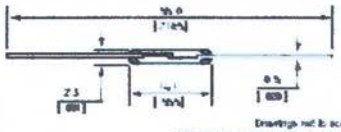
Literature Requests
www.atmel.com/literature

[illegible]

COMUS Group

COMUS International

Part Number GC2310 (0735) - Product Data Sheet
Reed Switch - Make Contact Form

PICTURE	DIMENSIONS
	

RoHS Compliant

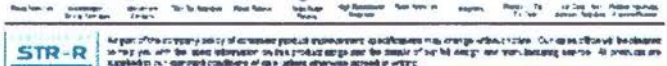
Drawings not to scale
All dimensions in mm [inches] nominal

SPECIFICATIONS		
Contact Form		A (Make Contact)
Contact Material		Rhodium
Switching Capacity	Max.	10 W/VA
Switching Voltage	Max.	180 VAC/DC
Switching Current	Max.	0.5 A
Carrying Current	Max.	1 A
Dielectric Strength	Min	300 VDC
Contact Resistance	Max.	50 mOhms
Insulation Resistance	Min	10^9 MOhms
Pull-In Sensitivity		7 - 35 AT
Drop-Out Sensitivity	Min	4 AT
Switching Time (Without Bounce)	Max.	1.0 ms
Bounce Time	Max.	0.5 ms
Release Time	Max.	0.05 ms
Resonant Frequency	Typ.	3000 Hz
Operating Frequency	Max.	200 Hz
Vibration	10 - 500	20 Hz
Shock	11 ms	30 G
Capacitance	Typ.	0.7 pF
Operating Temperature Range	Deg	-40 ~ +125°C
Life Expectancy	Min. Ops	10^8 Mech. Life
Test Coil	Type	GC36

ORDERING INFORMATION	NOTES
PART NUMBER GC 2310 XX XX • Type • Minimum Sensitivity (AT) • Maximum Sensitivity (AT) Example: Type 23 Relay with sensitivity between 20 - 30AT = PART NO. GC 2310 20 30	• The life expectancy of a reed switch is dependent upon the load being switched. At maximum rated loads life expectancy is measured in operations. Lower load ratings can increase the life up to 10 billion operations. Effective useful life of the reed switch can be at least 10 billion operations. Switching inductive capacitive or lamp loads can substantially reduce the life expectancy. • We offer a crimp and form service for Reed Switches to be customized to your specification.

REV. NO.	REVISION NOTE	DATE	SIGNATURE
2	Datasheet Redesign	29-Oct-07	MS

TAKE A LOOK AT OUR VARIETY OF PRODUCTS!



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Product Data Sheet
00813-0400-2654, Rev BA
September 2008

Rosemount 1075 and 1099 Series High-Temperature Thermocouples

- *Accurate temperature measurements in heat treatment and combustion processes*
- *Reliable temperature measurements in hot gas environments of ceramic and metals industries*
- *Ceramic protection tube materials available for use up to 1800 °C (3272 °F)*
- *Metal protection tube materials, such as Super Kanthal, for use up to 1700°C (3092 °F)*
- *Wide range of precious- metal and base-metal thermocouples*
- *Maximum measurement reliability obtained through calibration services*
- *Complete point solutions with integrated or remote temperature transmitter and mounting accessories*

Contents

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Product Data Sheet
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Rosemount 1075 and 1099 Series

Overview

Rosemount 1075 Series standard thermocouples conform to the requirements of the DIN EN 60584-1/2 (IEC 584) standards and are manufactured with premium materials. The DIN EN 50446 (now) standard defines all protection tube designs. By using a state-of-the-art manufacturing process, the thermocouples can be used in many different applications including the monitoring and control of process temperatures up to 1800 °C (3272 °F).

Our German Calibration Service (DKD) certified calibration laboratory performs thermocouple and resistance thermometer calibration for comparative and fixed point measurements for every customer sensor. As the equipment traceability requirements of DIN EN ISO 9000 become more stringent, Emerson Process Management keeps our customers internationally competitive by providing certificates and documents for quality assurance systems.

Technical References

Thermoelectric Effect

A thermocouple is a connection between two different metals that produces a change of the thermo-electric emf in comparison with a temperature change. It provides a thermo-electric voltage in millivolts D.C. dependant on the temperature difference between the hot (exposed to the measurement temperature) and cold (known temperature) junctions. A thermocouple has two different connected leads called positive and negative leg. These leads are connected to extension or compensating cable, or directly to the transmitter in the box connection head. The simplest thermocouple consists of two wires welded together at one end which form the measuring tip.

Thermocouple Materials

The IEC 584 (DIN EN 60584) standards define the basic values and tolerances of the thermocouple types at a temperature range between 0 °C (32 °F) and 1800 °C (3272 °F). For high temperature measurements from 1200 °C (2192 °F) to 1800 °C (3272 °F), a precious-metal thermocouple must be used. Generally, precious-metal (platinum) thermocouples are stable and can be used up to 1800 °C (3272 °F). See Table 1. The most commonly used base-metal thermocouple, Type K, covers most industrial applications.

TABLE 1. Characteristics of Standard Thermocouples

Thermocouple Type	Alloy of Leads +/-	Temperature Range	Output (mV dc)
K	[illegible]	0 to 1200 °C (32 to 2192 °F)	0 to 44.828
R	[illegible]	0 to 1400 °C (32 to 2552 °F)	0 to 14.242
S	[illegible]	0 to 1400 °C (32 to 2552 °F)	0 to 16.771
T	[illegible]	0 to 1400 °C (32 to 752 °F)	0 to 13.345

NOTE
Rosemount 1099 Series precious metal thermocouples (Type B, R, and S) need to be ordered using the model code. For more information, see Table 8 on page 15; Table 10 on page 18; Table 12 on page 22; and Table 14 on page 26.

Tolerances

All thermocouples manufactured and supplied by Emerson are in accordance with IEC 584-2 (DIN EN 60584-2) limit tolerances. Calibration of one or more customer-specific measuring points can be provided on request with a DKD certificate up to 1200 °C (2192 °F) and a works certificate ("WERKSZERTIFIKAT from Germany) up to 1300 °C (2372 °F).

Rosemount 1075 and 1099 Series

Important Information About High-Temperature Thermocouple Installation

To reduce risk of damage of gas tight, ceramic protection tubes by thermal shock, the thermocouple assembly needs to be pre-heated before installation. Slowly inserting the thermocouple into the ceramic protection tube avoids damage that could be caused by rapid change of temperature. Vertical assembly is recommended at high temperatures to avoid bending from the sensor's own weight. For horizontal assembly, additional support is required to avoid bending or breakage. A hair-line fracture can cause contamination and drift. The temperature at the connection head and the terminal block must not exceed 200 °C (392 °F).

Rosemount 1075 and 1099 Series

Standard Application Thermocouples

Introduction

The Rosemount 1075 Series thermocouples conform to DIN EN 60440 standard, and can be ordered as complete thermocouple assemblies.

TABLE 2. Thermocouple Type Selection Guide

Information Table	Type	Temp. Type/ Max. Temp	Diameter	Max. Length	Inner Tube Material
Table 5 on page 8	BM 316 SS with Metal Protection Tube (Max Temp. 1,200 °C [2192 °F])	K/1200 °C (2192 °F)	3 x 2 mm (0.50 x 0.08 in.)	2000 mm (78.74 in.)	Alloy 600
Table 6 on page 11	AM 316 SS with Metal Protection Tube (Max Temp. 1,200 °C [2192 °F])	K/1200 °C (2192 °F)	22 x 2 mm (0.87 x 0.08 in.)	6000 mm (236.22 in.)	Alloy 600
Table 7 on page 14	AMK 316 SS with Metal Protection Tube and Ceramic Inner Tube (Max Temp. 1350 °C [2462 °F])	R and S/ 1600 °C (2912 °F)	22 x 2 mm (0.87 x 0.08 in.)	6000 mm (236.22 in.)	C610
Table 9 on page 17	BK 316 SS with Ceramic Protection Tube (Max Temp. 1400 °C [2372 °F])	K/ 1200 °C (2192 °F) R and S/ 1600 °C (2912 °F) S/ 1600 °C (2372 °F)	10 x 1.5 mm (0.39 x 0.06 in.)	1000 mm (39.37 in.)	Alloy 600
Table 11 on page 20	AK 316 SS with Ceramic Protection Tube (Max Temp. 1400 °C [2372 °F])	K/ 1200 °C (2192 °F) R and S/ 1600 °C (2912 °F) S/ 1600 °C (2372 °F)	3 x 2 mm (0.50 x 0.08 in.) 15 x 2.5 mm (0.59 x 0.10 in.)	2000 mm (78.74 in.)	Alloy 600
Table 13 on page 24	AKK 316 SS with Ceramic Protection Tube and Inner Tube (Max Temp. 1600 °C [2372 °F])	K/ 1200 °C (2192 °F) R and S/ 1600 °C (2912 °F) S/ 1600 °C (2372 °F)	26 x 4 mm (1.02 x 0.16 in.) 24 x 3 mm (0.94 x 0.12 in.) 25 x 1 mm (0.98 x 0.20 in.)	2000 mm (78.74 in.)	C610/799

Thermocouple Design

TABLE 3. Tolerances of Thermocouples According to DIN EN 60584-2

Type	Alloy	Temperature Range	Tolerance DIN EN 60584-2	Tolerance Class
Base-Metal Thermocouples				
K	NiCr-Ni	-40 to 375 °C (-40 to 707 °F) 375 to 1,000 °C (707 to 1832 °F)	1.5 °C 0.004 x |t|	1
		-40 to 333 °C (-40 to 631 °F) 333 to 1,200 °C (631 to 2192 °F)	2.5 °C 0.0075 x |t|	2
Precious-Metal Thermocouples				
R	Pt13%Rh-Pt	0 to 1100 °C (32 TO 2012 °F) 1100 to 1600 °C (2012 to 2912 °F)	1.0 °C [1+0.003 x (t-1100 °C)]	1
		0 to 600 °C (32 TO 1112 °F) 600 to 1600 °C (1112 to 2912 °F)	1.5 °C 0.0025 x |t|	2
S	Pt10%Rh-Pt	0 to 1100 °C (32 TO 2012 °F) 1100 to 1600 °C (2012 to 2912 °F)	1.0 °C [1+0.003 x (t-1100 °C)]	1
		0 to 600 °C (32 TO 1112 °F) 600 to 1600 °C (1112 to 2912 °F)	1.5 °C 0.0025 x |t|	2
B	Pt30%Rh-Pt6%Rh	600 to 1,700 °C (1112 to 3092 °F)	0.0025 x |t|	2

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September 2008

Rosemount 1075 and 1099 Series

NOTE

Rosemount 1099 Series precious metal thermocouples (Types B, R, and S) need to be ordered using the model code. For more information, see Table 8 on page 15; Table 10 on page 18; Table 12 on page 22; and Table 14 on page 26.

The thermocouple wire diameter values with the design of the thermocouple. The standard diameter is 0.5 mm (0.02 in.) and is recommended for long term stability. However, a wire diameter of 0.35 mm (0.01 in.) is also available.

Protection Tube Design

A protection tube shields thermocouples from pressure, flow, corrosion, and mechanical and chemical influences. Selecting a suitable protection tube is crucial to the service life of the thermocouple assembly. Multiple designs using different materials and alloys were standardized for the use of our thermocouple assemblies. The Rosemount 1075 and 1099 Series offers a wide range of application specific protection tubes dependent on the process conditions.

Heat resistant metal protection tubes, such as Inconel or CrNi steel, provide high mechanical stress protection and can be used with temperatures up to 1200 °C (2192 °F). Emerson offers, as standard design, protection tubes of the following materials: AISI 446 (1.4762) and AISI 314 (1.4841). Protection tubes of Kanthal AF and Kanthal Super are also available for temperatures up to 1350 °C (2463 °F) or 1700 °C (3092 °F), e.g. in corrosive furnace atmospheres. Kanthal protection tubes can be used for multiple applications in refuse incinerators.

Ceramic protection tubes are used for high temperature ranges. Table 4 on page 6 identifies the characteristics and fields of application for standard materials and Ceramic Types C530, C610, and C799.

Gas-tight protection tubes made of silicon carbide are available upon request and are used in high dust loads and corrosive environments with temperatures of up to 1400 °C (2552 °F). Extended service life under extreme operating conditions is guaranteed by special characteristics of reactions sintered, silicon infiltrated silicon carbide protection tubes.

High temperature thermocouples are used for temperature measurements in heat treatment and combustion processes. They are also used in the hot gas environments including the glass, ceramic, and metal industries.

The most frequent applications are temperature monitoring and control of incinerators, industrial furnaces, and reactors.

The ceramic protection tube is usually cemented into a holding tube for easy installation of the connection head. Because the temperature above the fitting is generally lower, unalloyed steel is used for holding tubes. However, if a holding tube is exposed to the surface heat, heat resistant steel is used.

Rosemount 1075 and 1099 Series

TABLE 4. Protection Tube Material/Application Selection Guide

			Maximum Sizes		Protection Tube Material's Resistance to:				
Material	Max. Temperature	Suitable for High Pressure? (> 1 bar)	Pipe Dia (mm)	Length (mm)	Physical Gas Penetration	Thermal Shock	Chemical Sulfurous Gases	Chemical Nitrogenous Gases	Abrasion
Metal Protection Tubes									
1.4762 AISI 446	1200°C (2192°F)	Yes	16 x 2 22 x 2	2000 6000	No	High	High	Low	Low
1.4767 Kanthal AF™	1300 °C (2372°F)	Yes	22 x 2	6000	No	High	High	Low	Low
Kanthal Super™	1700 °C (3092°F)	Yes	22 x 4.5	1400	No	High	High	Low	Low
1.4841 AISI 314	1200 °C (2192°F)	Yes	16 x 2	2000	No	High	Low	High	Low
Ceramic Protection Tubes (DIN VDE 0126)									
Type C530 (Al_2O_3)	1400 °C (2192°F)	No	26 x 4	2000	Yes	Medium	High	High	High
Type C610 (60% Al_2O_3)	1400 °C (2552°F)	No	10 x 1.5 15 x 2.5	1000 2000	Yes	Low	High	High	High
Type C799 (99.7% Al_2O_3)	1400 °C (2372°F)	No	10 x 1.5 15 x 2.5	1000 2000	No	Low	High	High	High

Connection head versions that differ in size and type of cover are also available. All connection heads have a rubber o-ring seal on the cable entry that limits the temperature to approximately 80 °C (176 °F).

If using a silicone o-ring seal, the maximum temperature for the aluminum-alloy connection head is 200 °C (392 °F). Suitable connection heads are listed in "Accessories" on page 30.

In addition to our standard connection heads with inserted terminal blocks, thermocouples are also available with head-mounted transmitters (Rosemount 248 and 644 Series). These transmitters can be inserted into the cover of the connection head TZ-A/BL or TZ-IAL, but this reduces the maximum temperature the connection head can be exposed to 70 °C (158 °F).

A summary of some of the available transmitters is listed in "Accessories" on page 30.

The process connections are supplied with adjustable, removable and welded elements. We offer adjustable stop flanges, threaded fittings, adjustable flanges and welded flanges in a variety of sizes. All process connections are sealed except for the stop flanges.

Product Data Sheet
00813 0400 2654, Rev BA
September 2008

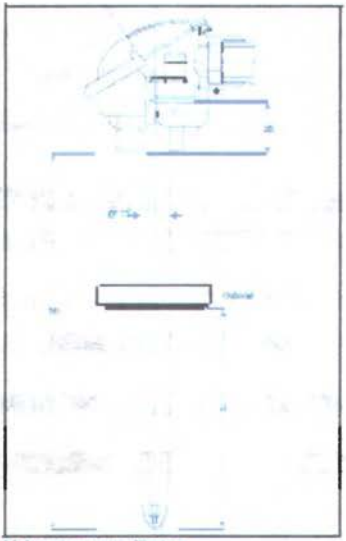
Rosemount 1075 and 1099 Series

1075 Series Immersion Thermocouples, with Metal Protection Tube (Form 1, Type BM)

This design consists of a ceramic insulated thermocouple with a protection tube housing, according to DIN EN 50446.

The thermocouple legs are insulated with ceramic elements. Oxidation can occur in Type K thermocouples operating between 800 and 1000 °C (1472 and 1832 °F) particularly in low-oxygen, and reducing atmospheres so minimally insulated thermocouple are recommended for these temperatures.

Protection tubes are available in standard heat resistance steel 1.4762 and 1.4841. Protection tubes made of material 1.4749 have no weld and are recommended for temperatures up to 1200 °C (2192 °F).



All dimensions are in millimeters

Rosemount 1075 and 1099 Series

TABLE 5. Order Table: Rosemount 1075 Series Immersion Thermocouples with Metal Protection Tube (Form 1, Type 6M)

Model	Product Description
1075	Thermocouple, IEC 584 (DIN EN 60584-1), Tolerance Class 1 acc. to IEC 584 (DIN EN 60584-2)

Model	Product Form
1	6M – DIN 6 with Metal Protection Tube (Max. Temp 1200 °C, Max length 2000 mm)

Code	Connection Head	IP Rating	Conduit Entry
C[11]	TZ-AXIL (BUZH), Aluminum	54	M20 x 1.5
U	CHAIL, Aluminum, DIN 43729	43	M20 x 1.5
Y	HHAXIL (BUS), Aluminum	54	M20 x 1.5

Code	Sensor Connection
2	Terminal Block Form B

Code	Number of Elements	Thermocouple Type
01	Single	K
02	Dual	K

Code	Thermocouple Type
K	K

Code	Wire Diameter (mm)	Thermocouple Type	Maximum Temperature (°C)
13	1.34 (Use with Dual Element)	K	1200
20	2 (Use with Single Element)	K	1200

Code	Protection Tube Material	Maximum Temperature (°C)
A	1.4762 (AISI 446), 14 x 2	1200
B	1.4841 (AISI 314), 14 x 2	1200

Code	Nominal Length (NL) (mm)
0250	250
0400	400
0710	710
1000	1000
XXXX	Other Lengths (Maximum 2,000)

Code	Process Connection	Material
A1	Adjustable Cap Flange (75 mm)	G ½ W-316 (cast iron)
B1	Adjustable Threaded Fitting with G ½	1.0711 (steel)
C4	Adjustable Flange 1 inch Class 150	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
C5	Adjustable Flange 1 inch Class 300	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
C6	Adjustable Flange 1 inch Class 600	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
D4	Adjustable Flange 1 ½ inch Class 150	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
D5	Adjustable Flange 1 ½ inch Class 300	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
D6	Adjustable Flange 1 ½ inch Class 600	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
E4	Adjustable Flange 2 inch Class 150	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
E5	Adjustable Flange 2 inch Class 300	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
E6	Adjustable Flange 2 inch Class 600	1.4571 (SS 316 Ti) Flange/1.0711 Steel Compression Fitting
F4[2]	Welded Flange 1 inch Class 150 Requires Flange Immersion Length (LBXXXX)	
F5[2]	Welded Flange 1 inch Class 300 Requires Flange Immersion Length (LBXXXX)	
F6[2]	Welded Flange 1 inch Class 600 Requires Flange Immersion Length (LBXXXX)	
G4[2]	Welded Flange 1 ½ inch Class 150 Requires Flange Immersion Length (LBXXXX)	
G5[2]	Welded Flange 1 ½ inch Class 300 Requires Flange Immersion Length (LBXXXX)	
G6[2]	Welded Flange 1 ½ inch Class 600 Requires Flange Immersion Length (LBXXXX)	
H4[2]	Welded Flange 2 inch Class 150 Requires Flange Immersion Length (LBXXXX)	
H5[2]	Welded Flange 2 inch Class 300 Requires Flange Immersion Length (LBXXXX)	
H6[2]	Welded Flange 2 inch Class 600 Requires Flange Immersion Length (LBXXXX)	
N1	No Fitting	

Code	Holding Tube Material/Length
N000	No Holding Tube

Continued on Next Page

TABLE 5. Order Table, Rosemount 1075 Series Immersion Thermocouples with Metal Protection Tube (Form 1, Type BM)

Model Code	Product Description Options
	Calibration Options
W02	Works Cert. Comparison measurement at 2 temperature points (Wm1605/Zert for IKA1)
W05	Works Cert. Comparison measurement at 5 temperature points (Wm1605/Zert for IKA1)
K02	DKD Calibration Cert. DKD Cert for 2 temperature points specified by customer
K05	DKD Calibration Cert. DKD Cert for 5 temperature points specified by customer
	Mounting Options
XA	Assembly sensor to temperature transmitter
	Welded Flange Options
U1H00	Length from Welded flange face to sensor tip (1400 mm) must be welded to Holding tube
U0000X	Length from Welded flange face to sensor tip Non-standard length (xxxx mm) must be welded to Holding tube
	Other Options
R24	DAD plate, stainless steel
MAN	Order specific drawing

(1) Connection head suitable for mounting a transmitter type (Rosemount 248 and 644)

(2) Welded flange immersion length (U) must not be greater than nominal length minus 15 mm. Immersion length (U) must not be less than Nominal length minus holding tube length (N) + 50.

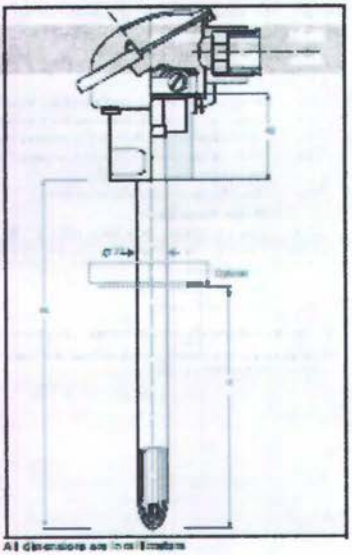
Product Data Sheet
00813-0400-2654, Rev BA
September 2008

Rosemount 1075 and 1099 Series

1075 Series Immersion Thermocouples with Metal Protection Tube (Form 2, Type AM)

This design consists of a base-metal thermocouple Type K, and a housing with a productive Design Type AM, according to DIN EN 50446. The thermocouple legs are insulated with ceramic elements.

A gas-tight threaded fitting is needed for gas-tight installation of the protection tube (pressure load of up to a maximum of 1 bar). Our standard heat-resistant materials for protection tubes are 1.4762 and 1.4841.



All dimensions are in millimeters

TABLE 6. Order Table: Rosemount 1075 Series Industrial Thermocouples with Metal Protection Tube (Form 2, Type AM)

Model	Product Description
1075	Thermocouple (IEC 584 (DIN EN 60584-1); Tolerance Class 1 also for IEC 584 (DIN EN 60584-2))

Model	Product Form
2	AM – DIN Style Metal Protection Tube (Max. temp. 1200 °C, Min. length 300 mm)

Code	Connection Head	IP Rating	Conduit Entry
B	B-A. (ALBI) Aluminium	54	M20 x 1.5
C[1]	T2-A. (AlUR) Aluminium	66	M20 x 1.5
P	DIN-A. Aluminium, DIN 43729	43	M20 x 1.5

Code	Sensor Connection
2	Terminal Block, Form B

Code	Number of Elements	Thermocouple Type
01	Single	K
02	Dual	K

Code	Thermocouple Type
K	K

Code	Wire Diameter (mm)	Thermocouple Type	Maximum Temperature (°C)
20	2.0 (dual)	K	1200
30[2]	3.0 (single)	K	1200

Code	Protection Tube Material	Maximum Temperature (°C)
C	1.4762 (X 9 CrNiSiAl 24 22 2)	1200 / K
D	1.4841 (X 15 CrNiSi 25 21)	1200 / K

Code	Nominal Length (NL) (mm)
0400	400
0710	710
1000	1000
1400	1400
XXXX	Other Length (Maximum 6000)

Code	Process Connection	Material
AJ	Adjustable Hex Flange (22 mm)	CrNi 316 (cast iron)
B2	Adjustable Threaded Ring with G 1	1.4571 (cast)
C4	Adjustable Flange 1 inch Class 150	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
C5	Adjustable Flange 1 inch Class 300	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
C6	Adjustable Flange 1 inch Class 600	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
D4	Adjustable Flange 1 ½ inch Class 150	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
D5	Adjustable Flange 1 ½ inch Class 300	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
D6	Adjustable Flange 1 ½ inch Class 600	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
E4	Adjustable Flange 2 inch Class 150	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
E5	Adjustable Flange 2 inch Class 300	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
E6	Adjustable Flange 2 inch Class 600	1.4571 (S 5316 Ti) Flange/1.4571 Steel Compression Ring
F4[3]	Welded Flange 1 inch Class 150 Requires Flange Immersion Length (UXXXX)	
F5[3]	Welded Flange 1 inch Class 300 Requires Flange Immersion Length (UXXXX)	
F6[3]	Welded Flange 1 inch Class 600 Requires Flange Immersion Length (UXXXX)	
G4[3]	Welded Flange 1 ½ inch Class 150 Requires Flange Immersion Length (UXXXX)	
G5[3]	Welded Flange 1 ½ inch Class 300 Requires Flange Immersion Length (UXXXX)	
G6[3]	Welded Flange 1 ½ inch Class 600 Requires Flange Immersion Length (UXXXX)	
H4[3]	Welded Flange 2 inch Class 150 Requires Flange Immersion Length (UXXXX)	
H5[3]	Welded Flange 2 inch Class 300 Requires Flange Immersion Length (UXXXX)	
H6[3]	Welded Flange 2 inch Class 600 Requires Flange Immersion Length (UXXXX)	
NN	No fitting	

Code	Holding Tube Material/Length
N000	No Holding Tube

Continued on Next Page

Rosemount 1075 and 1099 Series

TABLE 8. Order Table: Rosemount 1075 Series Immersion Thermocouples with Metal Protection Tube (Form 2, Type A81)

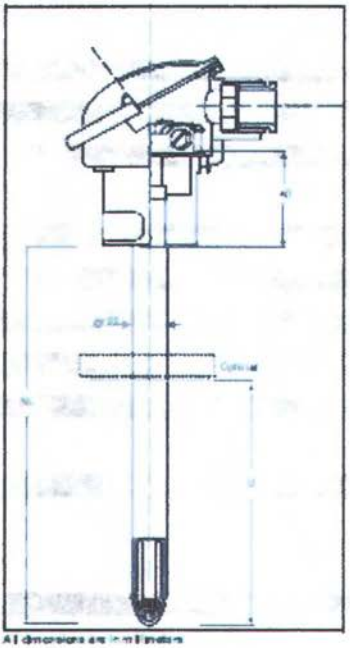
Model Code	Product Description Options
	Calibration Options
W02	Work s Cert: Comparison measurement at 12 measurement points (WERKSZEUGNIS)
W0A	Work s Cert: Comparison measurement at with 5 measurement points (WERKSZEUGNIS)
K02	DKD Calibration Cert, DKD Cert. for 2 temperature points specified by customer
K05	DKD Calibration Cert, DKD Cert. for 5 temperature points specified by customer
	Mounting Options
XA	Access the sensor to temperature transmitter
	Welded Flange Options
U1N-00	Length from Welded flange face to sensor tip (1400 mm) must be welded to drilling hole
U3XXX-	Length from Welded flange face to sensor tip (non-standard length (xxxx mm) must be welded to drilling hole
	Other
P24	TAG plate, stainless steel
MW	Order specific drawing

(1) Connection head suitable for mounting a transmitter (Rosemount 248 and 644)

(2) 3 mm sensor only, ordering more rapidly

(3) Welded flange insertion length (U) must not be greater than needed length minus ID mm. Immersion length (IL) must not be less than (length of neck minus welding tube length 95 - 10).

1075 Series Immersion Thermocouples with Metal Protection Tube and with Ceramic Inner Tube (Form 3, Type AMK)



All dimensions are in millimeters

This design consists of precious metal thermocouples Types R, S, or B, and a housing with a protection tube design Type AMK, according to DIN EN 50446. Precious metal thermocouples are insulated with a Ceramic insulating rod and have a gas tight inner tube of 15 x 2 mm (0.59 x 0.08 in.).

A gas-tight threaded fitting is needed for gas-tight installation of the protection tube (pressure load of up to a maximum of 1 bar). Our standard heat resistant materials for protection tubes are 1.4762 and 1.4841. We also have a protection tube type made of heat resistant Kanthal with an outer diameter of 22 mm (0.87 in.).

Protection tubes of Kanthal AF offer the following advantages:

- Temperature resistance to 1350 °C (2462 °F)
- Longer service life with a wall thickness of 2.0 mm (0.08 in.)
- Greater heat transfer because low wall thickness leads to a better response time
- Greater temperatures create a form fitting alumina film that keeps away impurities
- Resistance to oxidation that is superior to most iron and nickel base alloys

Rosemount 1075 and 1099 Series

TABLE 7. Order Table: Rosemount 1075 Series Immersion Thermocouples with Metal Protection Tube and with Ceramic Inner Tube (Form 3, Type AMK)

Model	Product Description		
1075	Thermocouple IEC 584 (DIN EN 60584-1), Tolerance Class 1 acc. to IEC 584 (DIN EN 60584-2)		
Model	**Product Form**		
3	AMK - DIN A with Metal Protection Tube and Ceramic Inner Tube (Max Temp 1260 °C, Max length 4000 mm)		
Code	**Connection Head**	**IP Rating**	**Conduit Entry**
E	H-AL (A-DE) Aluminium	54	M20 x 1.5
G[1]	T2-AL (A-DZF) aluminium	54	M20 x 1.5
P	DN-AL Aluminium, DIN 43729	43	M20 x 1.5
Code	**Sensor Connection**		
3	Terminal Block, Form A		
Code	**Number of Elements**		
XX	S, R, S Thermocouple wire specified in separate line XX-option required (See Model 1099 on Table 4)		
Code	**Thermocouple Type**		
X	S, R, S Thermocouple wire specified in separate line XX-option required (See Model 1099 on Table 4)		
Code	**Wire Diameter (mm)**	**Thermocouple Type**	**Maximum Temperature (°C)**
XX	S, R, S Thermocouple wire specified in separate line XX-option required (See Model 1099 on Table 4)		
Code	**Protection Tube Material**	**Inner Tube Material**	**Maximum Temperature (°C)**
E	1.4762 (AISI 446), 22 x 2	Type C610, 15 x 2	1200 / S, R, S
F	1.4841 (AISI 314), 22 x 2	Type C610, 15 x 2	1200 / S, R, S
G	1.4749 / Kanthal APT, 22 x 2	Type C610, 15 x 2	1350 / S, R, S
Code	**Nominal Length (IL) (mm)**		
0630	630		
0710	710		
1000	1000		
1400	1400		
XXXX	Other length (Maximum 4000)		
Code	**Process Connection**	**Material**	
A2	Adjustable slip flange (22 mm)	DIN-St (carbon)	
B2	Adjustable threaded fitting with G 1	1.0715 (steel)	
C0	Adjustable flange 1 inch Class 150	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
C5	Adjustable flange 1 inch Class 300	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
C6	Adjustable flange 1 inch Class 600	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
D0	Adjustable flange 1 1/2 inch Class 150	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
D5	Adjustable flange 1 1/2 inch Class 300	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
D6	Adjustable flange 1 1/2 inch Class 600	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
E0	Adjustable flange 2 inch Class 150	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
E5	Adjustable flange 2 inch Class 300	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
E6	Adjustable flange 2 inch Class 600	1.4571 (SS 2347) Flange/1.0711 Steel Compression fitting	
F0[2]	Welded flange 1 inch Class 150 Requires Flange immersion length (L0XXX)		
F5[2]	Welded flange 1 inch Class 300 Requires Flange immersion length (L0XXX)		
F6[2]	Welded flange 1 inch Class 600 Requires Flange immersion length (L0XXX)		
G0[2]	Welded flange 1 1/2 inch Class 150 Requires Flange immersion length (L0XXX)		
G5[2]	Welded flange 1 1/2 inch Class 300 Requires Flange immersion length (L0XXX)		
G6[2]	Welded flange 1 1/2 inch Class 600 Requires Flange immersion length (L0XXX)		
H0[2]	Welded flange 2 inch Class 150 Requires Flange immersion length (L0XXX)		
H5[2]	Welded flange 2 inch Class 300 Requires Flange immersion length (L0XXX)		
H6[2]	Welded flange 2 inch Class 600 Requires Flange immersion length (L0XXX)		
NN	No fitting		
N000	No thermowell		

Continued on the next page

TABLE 7. Order Table: Rosemount 1075 Series Immersion Thermocouples with Metal Protection Tube and with Ceramic Inner Tube (Form 3, Type AMK)

Model	Product Description		
Code	Options		
	Calibration Options		
W02	Work's Cert: Comparison measurement at 12 measurement points (WARKSZER TEST)		
W04	Work's Cert: Comparison measurement at 5 measurement points (WARKSZEUGNIS)		
Q02	DKD Calibration Cert, DKD Cert for 2 temperature points specified by customer		
Q04	DKD Calibration Cert, DKD Cert for 4 temperature points specified by customer		
	Mounting Options		
XA	Assemble sensor to temperature transmitter		
XB	Assemble to temperature thermocouple Model 1099 (Table 4)		
	Welded Flange Options		
J0500	Length from Welded flange face to sensor tip (500 mm) must be welded to shielding tube		
JXXXX	Length from Welded flange face to sensor tip (non-standard length (xxxx mm)) must be welded to shielding tube		
	Other		
Y24	TAG plate: stainless steel	Y26	TAG plate: stainless steel
Y99	Order specific drawing	Y99	Order specific drawing

(1) Connection head suitable for mounting a transmitter type (Rosemount 248 and 644)

(2) Welded flange immersion length (L) must be greater than welding length (WL) + flange thickness (FT). If given immersion length (L) is given as less than (welding length (WL) + FT), ...

TABLE 8. Order Table: Rosemount 1099 Series

Model	Product Description		
1099	Thermocouple (thermocouple wire assembled to model)		
Model	**Product Form**		
A1	Assembled to 1075 Form 3		
Code	**Number of Elements**		
01	Single		
02	Dual		
Code	**Thermocouple Type**		
R	R		
S	S		
B	B		
Code	**Wire Diameter (mm)**	**Thermocouple Type**	**Maximum Temperature (°C)**
03	0.35	B, R, S	1400/1,8 1600/3
05	0.5	B, R, S	1400/1,8 1600/3
Code	**Nominal Length (NL) (mm)**		
0400	400		
0710	710		
1000	1000		
1400	1400		
XXXX	Other lengths		
Code	**Additional Options**		
X3	Assemble to Model 1075		

Rosemount 1075 and 1099 Series

1075 Series Immersion Thermocouples with Ceramic Protection Tube (Form 4, Type BK)

This design consists of a base-metal thermocouple Type K or precious-metal thermocouples Type R, S, or B and a housing with a protection tube Type BK, according to DIN EN 50446.

The Single or Dual Type K thermocouple legs are insulated with ceramic elements.

Precious-metal thermocouples are insulated with a ceramic insulating rod.

Installation requires stop flanges and threaded fittings. Standard materials for the protection tubes are Ceramic Types C610 and C799, and the hold tube is made of materials AISI (1.4841), AISI 446 (1.4762) or mild steel (1.0305).

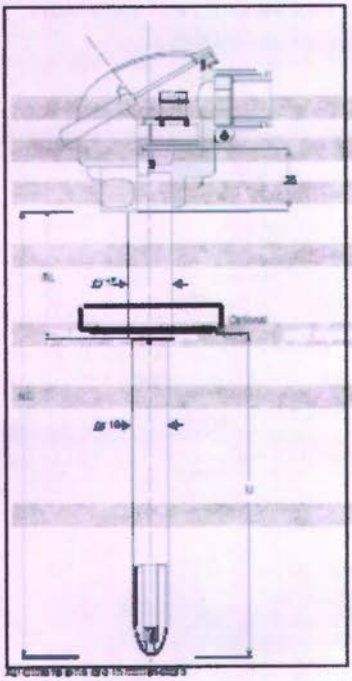


TABLE 5. Ordering Table: Rosemount 1075 Series, Integral Type Thermocouples with Ceramic Protection Tube (Form 4, Type RK)

Model	Product Description
1075	Thermocouple IEC 584 (DIN EN 60584-1), Tolerance Class 1 acc. to IEC 584 (DIN EN 60584-1)

Model	Product Form
4	RK – DIN B with Ceramic Protection Tube (Max. Temp 1600 °C, Max length 1000 mm)

Code	Connection Head	IP Rating	Conduit Entry
[illegible]	T (A.S.M.E. B1.20.1), Aluminum	54	M20 x 1.5
U	GP-A/B, Aluminum, DIN 43729	43	M20 x 1.5
Y	H-A/B, (B.S.P.), Aluminum	54	M20 x 1.5

Code	Sensor Connection
2	Terminal Block, Form B

Code	Number of Elements	Thermocouple Type
01	Single Type K thermocouple wire only	K
02	Dual Type K thermocouple wire only	K
XX	S, R, S Thermocouple wire specified in separate line (XS option required) (See Model 1099 or Table 10)	

Code	Thermocouple Type
K	K
X	S, R, S Thermocouple wire specified in separate line (XS option required) (See Model 1099 or Table 10)

Code	Wire Diameter [mm]	Thermocouple Type	Maximum Temperature [°C]
13	1.28	K	1200 K
XX	S, R, S Thermocouple wire specified in separate line (XS option required) (See Model 1099 or Table 10)		1400 / R, S 1450 / B

Code	Protection Tube Material	Inner Tube Material	Maximum Temperature [°C]
J	Type CR 799 / 10 x 1.5	without	1600 / K, 1400 / R, S
L	Type C799 / 10 x 1.5	without	1400 / R, S, 1450 / B

Code	Nominal Length (NL) [mm]
0250	250
0500	500
0710	710
XXXX	Other length (not Maximum 1000)

Code	Process Connection	Material
A1	Adjustable clip flange (70 mm)	C799 / K (stainless)
B1	Adjustable threaded fitting with G ½	1.0711 (steel)
C4	Adjustable Flange 1 inch Class 150	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
C5	Adjustable Flange 1 inch Class 300	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
C6	Adjustable Flange 1 inch Class 600	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
D4	Adjustable Flange 1 ½ inch Class 150	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
D5	Adjustable Flange 1 ½ inch Class 300	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
D6	Adjustable Flange 1 ½ inch Class 600	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
E4	Adjustable Flange 2 inch Class 150	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
E5	Adjustable Flange 2 inch Class 300	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
E6	Adjustable Flange 2 inch Class 600	1.4571 (SS316 Ti) Flange/1.0711 Steel Compression fitting
F4[2]	Welded Flange 1 inch Class 150 (requires Flange immersion length (JXXXX))	
F5[2]	Welded Flange 1 inch Class 300 (requires Flange immersion length (JXXXX))	
F6[2]	Welded Flange 1 inch Class 600 (requires Flange immersion length (JXXXX))	
G4[2]	Welded Flange 1 ½ inch Class 150 (requires Flange immersion length (JXXXX))	
G5[2]	Welded Flange 1 ½ inch Class 300 (requires Flange immersion length (JXXXX))	
G6[2]	Welded Flange 1 ½ inch Class 600 (requires Flange immersion length (JXXXX))	
H4[2]	Welded Flange 2 inch Class 150 (requires Flange immersion length (JXXXX))	
H5[2]	Welded Flange 2 inch Class 300 (requires Flange immersion length (JXXXX))	
H6[2]	Welded Flange 2 inch Class 600 (requires Flange immersion length (JXXXX))	
W1	No fitting	

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Rosemount 1075 and 1099 Series

TABLE 9. Ordering Table. Rosemount 1075 Series Immersion Thermocouples with Ceramic Protection Tube (Form 4, Type BK)

Model	Product Description
Code	Holding Tube Material
A	1.4762 (AISI 446), 15 x 2
B	1.4841 (AISI 314), 15 x 2
C	1.0305 (mild steel), 15 x 2
Code	**Holding Tube Length (mm)**
040	40
XXX	Other length
Code	**Options**
	Calibration Options
W2	Works Cert. Comparison measurement, at 2 measurement points (WERKSZEUGNIS KAT.)
W3	Works Cert. Comparison measurement, at 3 measurement points (WERKSZEUGNIS KAT.)
K02	DKD Calibration Cert. DKD Cert for 2 temperature points specified by customer
K03	DKD Calibration Cert. DKD Cert for 3 temperature points specified by customer
	Mounting Options
XA	Assemble gasket to compression fitting (1)
XB	Assemble to precious-metal thermocouple wire (Table 10)
	Welded Flange Options
U1500	Length from Welded Flange face to sensor tip (1500 mm) must be welded to Holding tube
UXXXX	Length from Welded Flange face to sensor tip (Non-Standard length (xxxx mm) must be welded to Holding tube
	Other
Y24	TAG plate, stainless steel
Y29	Other special drawing

(1) Connection head adapter for mounting a transmitter into Dimension 240 and 300

(2) Weight flange immersion length (U) must not be greater than nominal length minus 50mm. Immersion length (IL) must not be less than threaded length plus holding tube length (HL + 50).

TABLE 10. Order Table Rosemount 1099 Series

Model	Product Description
1099	Precious-metal thermocouple wire assembly to model
Model	**Product Form**
A4	Assembled to 1075 Form 4
Code	**Number of Elements**
01	Single
02	Dual
Code	**Thermocouple Type**
B	B
R	R
S	S

Code	Wire Diameter (mm)	Thermocouple Type	Maximum Temperature (°C)
03	0.35	B, R, S	1400(R, S: 1600)
05	0.5	B, R, S	1400(R, S: 1600)

Code	Nominal Length (NL) (mm)
0250	250
0500	500
0710	710
XXXX	Other Lengths (Maximum 1000)
Code	**Additional Options**
XB	Assemble to Model 1075

Product Data Sheet
00813-0400-2654, Rev BA
September 2008

Rosemount 1075 and 1099 Series

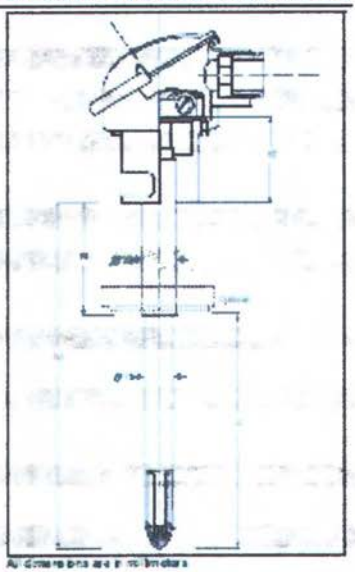
1075 Series Immersion Thermocouple with Ceramic Protection Tube (Form 5, Type AK)

The design consists of a base metal thermocouple Type K or precious metal thermocouples Type R, S, or B and a housing with a protection tube Type AK, according to DIN EN 50446.

The Single or Dual Type K thermocouple tips are insulated with ceramic elements.

Precious metal thermocouples are insulated with a ceramic insulating rod.

Installation requires stop flanges and threaded fittings. Standard materials for the protection tubes are Ceramic Types C610 and C799 and the holding tube is made of materials AISA 314 (1.4841), AISI 446 (1.4762), or mild steel (1.0305).



All dimensions are in millimeters

Rosemount 1075 and 1099 Series

TABLE 11. Order Table: Rosemount 1075 Series Immersion Thermocouple with Ceramic Protection Tube (Form 5, Type AK)

Model	Product Description		
1075	Thermocouple IEC 584 (DIN EN 60584-1), Tolerance Class 1 acc. to IEC 584 (DIN EN 60584-2)		
Model	**Product Form**		
5	AK - DIN A with Ceramic Protection Tube (Max Temp 1800 °C, Max length 2000 mm)		
Code	**Connection Head**	**IP Rating**	**Conduit Entry**
T	TH-AL (ALSi), Aluminum	54	M20 x 1.5
G[1]	TZ-AL (ALSi), Aluminum	54	M20 x 1.5
P	DIN-AL, Aluminum, DIN 43729	43	M20 x 1.5
Code	**Sensor Connection**		
3	Terminal Block, Form A		
Code	**Number of Elements**	**Thermocouple Type**	
01	Single	K	
02	Dual	K	
XX	S, R, S Thermocouple wire specified in separate line XX option required (See Model 1075 on Table 12)		
Code	**Thermocouple Type**		
K	K		
X	S, R, S Thermocouple wire specified in separate line XX option required (See Model 1075 on Table 12)		
Code	**Wire Diameter (mm)**	**Thermocouple Type**	**Maximum Temperature (°C)**
13	1.38 (Dual)	K	1,000
30	3.0 (Single)	K	1,200
XX	S, R, S Thermocouple wire specified in separate line XX option required (See Model 1075 on Table 12)		
Code	**Protection Tube Material**	**Inner Tube Material**	**Maximum Temperature (°C)**
P	Type C610, 15 x 2	without	1200 / K; 1400 / R, S
R	Type C799, 15 x 2	without	1400 / R, S; 1600 / S
Code	**Nominal Length (IE) (mm)**		
0400	400		
0710	710		
1000	1000		
1400	1400		
XXXX	Other lengths (Maximum 2,000)		
Code	**Process Connection**	**Material**	
A2	Adjustable clip flange (22 mm)	GTW-35 (cast iron)	
B2	Adjustable threaded fitting with G 1	1.0711 (steel)	
C4	Adjustable Flange 1 inch Class 150	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
C5	Adjustable Flange 1 inch Class 300	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
C6	Adjustable Flange 1 inch Class 600	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
D4	Adjustable Flange 1 1/2 inch Class 150	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
D5	Adjustable Flange 1 1/2 inch Class 300	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
D6	Adjustable Flange 1 1/2 inch Class 600	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
E4	Adjustable Flange 2 inch Class 150	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
E5	Adjustable Flange 2 inch Class 300	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
E6	Adjustable Flange 2 inch Class 600	1.4571 (SS316Ti) Flange/1.0711 Steel Compression fitting	
H4[2]	Welded Flange 1 inch Class 150 Requires Flange immersion length (L)XXXX)		
H5[2]	Welded Flange 1 inch Class 300 Requires Flange immersion length (L)XXXX)		
H6[2]	Welded Flange 1 inch Class 600 Requires Flange immersion length (L)XXXX)		
G4[2]	Welded Flange 1 1/2 inch Class 150 Requires Flange immersion length (L)XXXX)		
G5[2]	Welded Flange 1 1/2 inch Class 300 Requires Flange immersion length (L)XXXX)		
G6[2]	Welded Flange 1 1/2 inch Class 600 Requires Flange immersion length (L)XXXX)		
J4[2]	Welded Flange 2 inch Class 150 Requires Flange immersion length (L)XXXX)		
J5[2]	Welded Flange 2 inch Class 300 Requires Flange immersion length (L)XXXX)		
J6[2]	Welded Flange 2 inch Class 600 Requires Flange immersion length (L)XXXX)		
N5	No fitting		

Continued on Next Page

Rosemount 1075 and 1099 Series

TABLE 11. Order Table: Rosemount 1075 Series Mineral Insulated Thermocouple with Ceramic Protection Tube (Form 5, Type AK)

Model	Product Description	
Code	Holding Tube Material	Dimensions in Millimeters
D	1.4562 (AISI 446)	.22 x 2
E	1.4841 (AISI 314)	.22 x 2
F	1.0305	.22 x 2
Code	**Holding Tube Length (mm)**	
[illegible]	[illegible]	
XXX	Other length	
Code	**Options**	
	Calibration Options	
WC2	Works Cert. Comparison measurement at 2 measurement points (WC2/KA1)	
WC5	Works Cert. Comparison measurement at 5 measurement points (WC5/KA1)	
4G2	UKAS Calibration Cert. UKAS Cert. for 2 temperature points specified by customer	
4G5	UKAS Calibration Cert. UKAS Cert. for 5 temperature points specified by customer	
	Bending Options	
XA	Assemble sensor to temperature transmitter	
X5	[illegible] Thermocouple wire specified in separate line (X5 option required) (See Model [illegible] Table 12)	
	Welded Flange Options	
U1500	Length from Welded flange face to sensor tip (1500 mm) must be welded to Holding tube	
UXXXX	Length from Welded flange face to sensor tip (Non-Standard length (xxxx mm) must be welded to Holding tube	
	Other	
Y04	Acceptable examination	
4B93	Order specific drawing	

(1) Connector head suitable for mounting a transmitter (add dimension 141 mm/5.6")

(2) Welded flange insertion length (U) must be greater than nominal length minus 50mm. Immersion length (X) must be less than Nominal length minus holding tube length (N) - (L).

Rosemount 1075 and 1099 Series

TABLE 12. Order Table Rosemount 1099 Series

Model	Product Description
1099	Premium-purity thermocouple wire assembly to model
Model	**Product Form**
XX	Assembled to 1075 Family
Code	**Number of Elements**
01	Single
02	Dual
Code	**Thermocouple Type**
B	B
R	R
S	S

Code	Wire Diameter (mm)	Thermocouple Type	Maximum Temperature (°C)
03	0.25	B, R, S	1482°C (2700°F)
04	0.5	B, R, S	1482°C (2700°F)

Code	Nominal Length (NL) (mm)
0430	430
0710	710
1000	1000
1400	1400
XXXX	Other Lengths (Maximum 2000)
Code	**Additional Options**
XS	Assemble to Model 1075

Product Data Sheet
00813 0400 2654, Rev BA
September 2008

Rosemount 1075 and 1099 Series

1075 Series Immersion Thermocouple with Ceramic Protection Tube and Ceramic Inner Tube (Form 6, Type AKK)

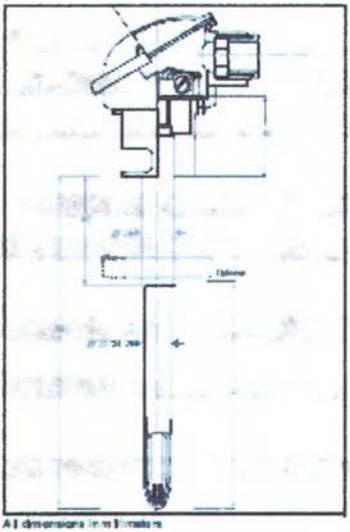
This design consists of a base metal thermocouple Type K or precious metal thermocouples Type R, S or B and a housing with a protection tube Type AKK, according to DIN EN 50446.

The Single or Dual Type K thermocouple tips are insulated with ceramic elements.

Precious metal thermocouples are insulated with a 4-hole insulating rod and provided a gas-tight inner tube made of Ceramic Type C610 or C799.

Installation requires stop flanges or threaded fittings. Standard materials for the protection tubes are Ceramic Types C530, C610 and C799.

Gas-tight ceramic materials are sensitive to thermal shock and stress impact with a tolerance level that can be optimized by selecting the proper materials for protection and inner tubes.



All dimensions in millimeters

For recommended combinations of ceramic protection and inner tube combinations, consult with your Emerson representative.

The standard holding tube is made of material 1.0305 and is recommended for temperatures to 200 °C (392 °F). For temperatures exceeding 200 °C (392 °F), the Rosemount 1075 Series offers holding tubes made of heat resistant materials AISI 446 (1.4762) or AISI 314 (1.4841).

Kanthal Super protection tubes consist of sintered material and have the following properties:

- Temperature resistant to 1700 °C (3092 °F)
- Not as porous or brittle, and can be used in higher temperatures and in corrosive furnace atmospheres
- Suppress electromagnetic noise that could disturb the thermocouple function

Rosemount 1075 and 1099 Series

TABLE 13. Ordering Table: Rosemount 1075 Series Immersion Thermocouple with Ceramic Protection Tube and Ceramic Inner Tube (Form 6, Type AKK)

Model	Product Description
1075	Thermocouple, IEC 584 (DIN EN 60584-1), Tolerance Class 1 acc. to IEC 584 (DIN EN 60584-2)

Model	Product Form
K	AKK - DIN A with Ceramic Protection Tube and Inner Tube (Max Temp 1600 °C, Max length 2000 mm)

Code	Connection Head	IP Rating	Conduit Entry
E	H14A, (AlSi), Aluminum	54	M20 x 1.5
G[1]	T44A, (AlSi10), aluminum	54	M20 x 1.5
P	G16A, Aluminum, DIN 43729	43	M20 x 1.5

Code	Sensor Connection
3	Terminal Block, Form A

Code	Number of Elements	Thermocouple Type
01	Single	K
02	Dual	K
XX	S, H, S, Thermocouple wire specified in separate line (XX option required (See Model 1099 or Table 14)	

Code	Thermocouple Type
K	K
X	S, H, S, Thermocouple wire specified in separate line (XX option required (See Model 1099 or Table 14)

Code	Wire Diameter (mm)	Maximum Temperature (°C)
20	2.0 Type K, Dual Element	1200
30	3.0 Type K, Single Element	1200
XX	S, H, S, Thermocouple wire specified in separate line (XX option required (See Model 1099 or Table 14)	

Code	Protection Tube Material	Inner Tube Material	Maximum Temperature (°C)
H	Ceramic Supa (Maximum length 1400 mm), 22 x 4.5	Type C799, 10 x 1.5	1700 / S
T	Type C530, 26 x 4	Type C610, 15 x 2	1200 / K, 1400 / H, S
V	Type C530, 28 x 4	Type C799, 15 x 2.5	1600 / H, S
W	Type C799, 24 x 3	Type C799, 15 x 2.5	1200 / S, H, S

Code	Nominal Length (IN) (mm)
0500	500
0710	710
1000	1000
1400	1400
2000	2000
XXXX	Other lengths (Maximum 2,000; 500 for process temperature H)

Code	Process Connection	Material
A1	Adjustable slip flange (32 mm)	GTW-15 (cast iron)
B3	Adjustable threaded fitting with G 1 1/4	1.0711 (steel)
C4	Adjustable Flange 1 inch Class 150	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
C5	Adjustable Flange 1 inch Class 300	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
C6	Adjustable Flange 1 inch Class 600	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
D4	Adjustable Flange 1 1/2 inch Class 150	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
D5	Adjustable Flange 1 1/2 inch Class 300	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
D6	Adjustable Flange 1 1/2 inch Class 400	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
E4	Adjustable Flange 2 inch Class 150	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
E5	Adjustable Flange 2 inch Class 300	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
E6	Adjustable Flange 2 inch Class 600	1.4571 (S31635) Flange/1.0711 Steel Compression fitting
F4[2]	Welded Flange 1 inch Class 150 Requires Flange connection length (U0000)	
F5[2]	Welded Flange 1 inch Class 300 Requires Flange connection length (U0000)	
F6[2]	Welded Flange 1 inch Class 600 Requires Flange connection length (U0000)	
G4[2]	Welded Flange 1 1/2 inch Class 150 Requires Flange connection length (U0000)	
G5[2]	Welded Flange 1 1/2 inch Class 300 Requires Flange connection length (U0000)	
G6[2]	Welded Flange 1 1/2 inch Class 400 Requires Flange connection length (U0000)	
H4[2]	Welded Flange 2 inch Class 150 Requires Flange connection length (U0000)	

Continued on Next Page

Rosemount 1075 and 1099 Series

TABLE 13. Ordering Table Rosemount 1075 Series Immersion Thermocouple with Ceramic Protection Tube and Ceramic Inner Tube (Form 6, Type AKK)

Model	Product Description		
Code	Process Connection	Material	
[illegible]	Welded Flange 2 inch Class 300 Flanged Flange immersion length (UXXXX)		
TH	Tri-Clamp		
Code	**Holding Tube Material**		
C	1.4762 (AISI 446) 32 x 2		
H	1.4841 (AISI 314) 32 x 2		
J	1.4835 32 x 2		
Code	**Holding Tube Length (mm)**		
200	200	200	200 mm
XXX	Other length	XXX	Other length
Code	**Options**		
	Calibration Options		
[illegible]	Works Cert. Comparison measurement (4) 2 measurement points (WERKS.ZEUGNIS für KAT.)		
[illegible]	Works Cert. Comparison measurement (4) 5 measurement points (WERKS.ZEUGNIS für KAT.)		
KC2	DKD Calibration Cert. DKD Cert for 2 temperature points specified by customer		
KC5	DKD Calibration Cert. DKD Cert for 5 temperature points specified by customer		
	Mounting Options		
XA	Assemble sensor to temperature transmitter		
XS	Assemble predocumented thermocouple wire (S, R, B) Model 1099 on Table 14		
	Welded Flange Options		
UF100	Length from Welded Flange face to sensor tip (1500 mm) must be welded to Holding tube		
UXXXX	Length from Welded Flange face to sensor tip Non-Standard length (4digit mm) must be welded to Holding tube		
	Other		
Y24	TAG plate, stainless steel	Y24	TAG plate, stainless steel
Y99	Order specific drawing	Y99	Order specific drawing

(1) Connection head suitable for mounting a transmitter inside (Rosemount 248 and 644)

(2) Welded flange immersion length (U) must not be greater than nominal length minus 50 mm. Immersion length (U) must not be less than Nominal length minus Holding tube length (XL + 50)

Rosemount 1075 and 1099 Series

TABLE 14. Order Table, Rosemount 1099 Series

Model	Product Description
1099	Precompensated thermocouple transmitter for installation in sensor
Model	**Product Pairs**
AR	Assembled to 1075 Family
Code	**Number of Elements**
01	Single
02	Dual
Code	**Thermocouple Type**
B	B
R	R
S	S
Code	**Wire Diameter (mm)**	**Thermocouple Type**	**Maximum Temperature (°C)**
03	0.33	B, R, S	1400/R, S; 1800/
05	0.5	B, R, S	1400/R, S; 1800/B
Code	**Nominal Length (NL) (mm)**
0600	600
0710	710
1000	1000
1400	1400
2000	2000
XXXX	Other Lengths Non-Standard Nominal Length
Code	**Additional Options**
XR	Assembled to Model 1075

Rosemount 1075 and 1099 Series

Calibration and Certificates

Calibration with DKD Certificate

The calibration of temperature sensors is done in our DKD calibration laboratory accredited according to DIN EN ISO/IEC 17025: 2005.

The Deutscher Kalibrierdienst (DKD) is an association of calibration laboratories including industrial firms research institutes, technical authorities, inspection and testing institutes.

The DKD calibration certificates provide traceability to national standards as required in the standard's family ISO 9000 and the ISO/IEC 17025 which allow the user to trust the reliability of the measurement results.

While compiling a DKD or works certificate, the thermocouple or measuring system is checked using comparison standards regarding measurement accuracy.

Our laboratory is authorized to issue DKD calibration certificates for temperature in the measurement ranges shown in Table 15 on page 27. The measurement uncertainties are defined in the various calibration points and based on the dual standard deviation ($k = 2$), (probable coincidence approximately 95%).

The calibrations carried out by our laboratory are services provided to the customer. Our intention is to meet the quality requirements of the customer in relation to thermocouple calibration, including traceability to national standards and accomplishing the contract commitments with the accreditation authority DAR (German Accreditation Council). The thermocouple, which provides the measurement result on its own or as a measuring chain, is compared with the national standards. This comparison measurement produces quantitative verification of traceability.

A report is issued in the form of a calibration certificate according to DKD specifications (Figure 2 on page 29).

TABLE 15. DKD Laboratory Accreditation Ranges for Thermocouple Calibration

Subject of Calibration	Temperature Range	Measurement Conditions	Measurement Uncertainty	Remarks
Thermocouples	0 to 1,200 °C (32 to 2,192 °F)	Comparison with standard thermocouples in tube furnaces	1 K	
Thermocouples Type S and R	0 to 1100 °C (32 to 2012 °F)		1K	Contact error when calibrating type S and R
Measuring inserts with connected thermocouples	same as for thermocouples	same as for thermocouples	U(T95) = 1.0(Umc) K	U(T95) is the measurement uncertainty of calibrating the thermocouple by itself

Works Certificates (WERKSZERTIFIKAT)

Thermocouples with a works certificate show documentation of measurements in the service and quality assurance department.

Using the comparison method, the calibrated values are certified on a works certificate. The maximum test temperature is 1300 °C (2372 °F).

The customer must specify the number and values of the calibrated test variables.

NOTE
Before specifying a temperature value, consider the temperature limits of the thermocouple. For individual order options see the Ordering Tables.

FIGURE 1. DAR Accreditation Certificate

Deutscher Kalibrierdienst (DKD)
Accreditation Body

Deutscher AkkreditierungsRat

Accreditation

Temperature

DAR registration number: DKD-K-05601
DKD accredited since: 1997-03-24

Braunschweig, 2007-05-25

FIGURE 2. DKD Certificate and Test Report Example

Rosemount 1075 and 1099 Series

Accessories

Transmitters

Rosemount head-mounted transmitters 248H and 644H can be assembled to the extended cover of the connection head Types TZ-A(B)L (B(JZ)H) or TZ-AL (A(JZ)H). These transmitters have the following common properties:

- Complete installation ready assembly
- Improved accuracy with cold junction, and ambient temperature compensation
- Micro Processor controlled, with user selectable inputs and 4-20mA/HART® or Foundation™ fieldbus communication protocols
- Meets NAMUR NE 21, and is resistant to Radio Frequency and Electro Magnetic Interference
- Epoxy sealed electronics ensure reliable performance

The Rosemount 3144P transmitter can be ordered and assembled to the 1075 thermocouple. The 3144P features a sealed dual-compartment housing, an LCD meter display, Hot Backup sensor redundancy, and a Thermocouple Diagnostic function to detect drifting thermocouple conditions.

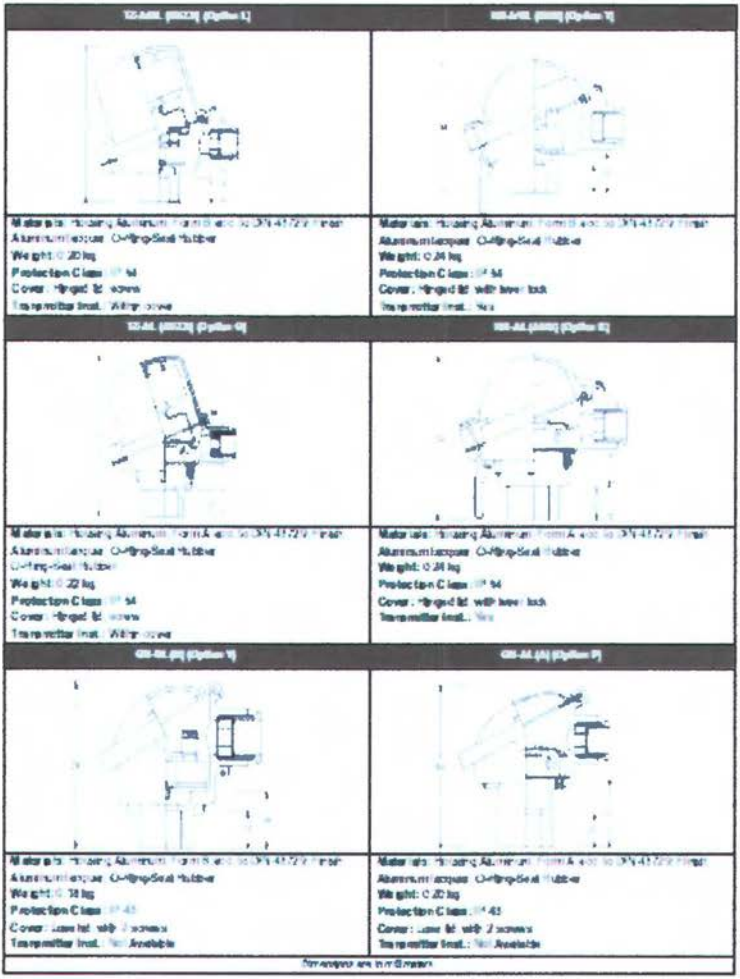
The Rosemount 848T Multi-Input Temperature Transmitter is capable of accepting up to eight thermocouple inputs into one transmitter. The 848T is ideally suited for high density temperature measurement applications.

Connection Head

Figure 3 on page 31 shows the technical data of the connection heads mentioned in the Product Data Sheet. The screw cable gland is available with thread M 20 x 1.5.

Rosemount 1075 and 1099 Series

FIGURE 3. Connection Head Dimensional Drawings and Information (A) Temperature Limits -40 to 80°C (-40 to 176°F)



Rosemount 1075 and 1099 Series

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EMERSON
Process Management

Istilah **plastik** mencakup produk polimerisasi sintetik atau semi-sintetik. Mereka terbentuk dari kondensasi organik atau penambahan polimer dan bisa juga terdiri dari zat lain untuk meningkatkan performa atau ekonomi. Ada beberapa polimer alami yang termasuk plastik. Plastik dapt dibentuk menjadi film atau fiber sintetik. Nama ini berasal dari fakta bahwa banyak dari mereka "malleable", memiliki properti keplastikan. Plastik didesain dengan varias yang sangat banyak dalam properti yang dapat menoleransi panas, keras, "reliency" dan lain-lain. Digabungkan dengan kemampuan adaptasinya, komposisi yang umum dan beratnya yang ringan memastikan plastik digunakan hampir di seluruh bidang industri.

Pellet atau bijih plastik yang siap diproses lebih lanjut (injection molding, ekstrusi, dll)

Plastik dapat juga menuju ke setiap barang yang memiliki karakter yang deformasi atau gagal karena shear stress- lihat keplastikan (fisika) dan ductile.

Plastik dapat dikategorisasikan dengan banyak cara tapi paling umum dengan melihat tulang-belakang polimernya

(vinyl{chloride}, polyethylene, acrylic, silicone, urethane, dll.). Klasifikasi lainnya juga umum.

Plastik adalah polimer; rantai-panjang atom mengikat satu sama lain. Rantai ini membentuk banyak unit molekul berulang, atau "monomer". Plastik yang umum terdiri dari polimer karbon saja atau dengan oksigen, nitrogen, chlorine atau belerang di tulang belakang. (beberapa minat komersial juga berdasar silikon). Tulang-belakang adalah bagian dari rantai di jalur utama yang menghubungkan unit monomer menjadi kesatuan. Untuk mengeset properti plastik grup molekuler berlainan "bergantung" dari tulang-belakang (biasanya "digantung" sebagai bagian dari monomer sebelum menyambungkan monomer bersama untuk membentuk rantai polimer). Pengesetan ini oleh grup "pendant" telah membuat plastik menjadi bagian tak terpisahkan di kehidupan abad 21 dengan memperbaiki properti dari polimer tersebut.

Pengembangan plastik berasal dari penggunaan material alami (seperti: permen karet, "shellac") sampai ke material alami yang dimodifikasi secara kimia (seperti: karet alami, "nitrocellulose") dan akhirnya ke molekul buatan-manusia (seperti: epoxy, polyvinyl chloride, polyethylene).

[sunting] Sejarah

Plastik merupakan material yang baru secara luas dikembangkan dan digunakan sejak abad ke-20 yang berkembang secara luar biasa penggunaannya dari hanya beberapa ratus ton pada tahun 1930-an, menjadi 150 juta ton/tahun pada tahun 1990-an dan 220 juta ton/tahun pada tahun 2005. Saat ini penggunaan material plastik di negara-negara Eropa Barat mencapai 60kg/orang/tahun, di Amerika Serikat mencapai 80kg/orang/tahun, sementara di India hanya 2kg/orang/tahun.[1]

[sunting] Jenis plastik

Plastik dapat digolongkan berdasarkan:

- **Sifat fisikanya**

- *Termoplastik*. Merupakan jenis plastik yang bisa didaur-ulang/dicetak lagi dengan proses pemanasan ulang. Contoh: polietilen (PE), polistiren (PS), ABS, polikarbonat (PC)
- *Termoset*. Merupakan jenis plastik yang tidak bisa didaur-ulang/dicetak lagi. Pemanasan ulang akan menyebabkan kerusakan molekul-molekulnya. Contoh: resin epoksi, bakelit, resin melamin, urea-formaldehida

- **Kinerja dan penggunaanya**
  - *Plastik komoditas*
    - sifat mekanik tidak terlalu bagus
    - tidak tahan panas
    - ontohnya: PE, PS, ABS, PMMA, SAN
    - Aplikasi: barang-barang elektronik, pembungkus makanan, botol minuman
  - *Plastik teknik*
    - Tahan panas, temperatur operasi di atas 100 °C
    - Sifat mekanik bagus
    - Contohnya: PA, POM, PC, PBT
    - Aplikasi: komponen otomotif dan elektronik
  - *Plastik teknik khusus*
    - Temperatur operasi di atas 150 °C
    - Sifat mekanik sangat bagus (kekuatan tarik di atas 500 Kgf/cm^2)
    - Contohnya: PSF, PES, PAI, PAR
    - Aplikasi: komponen pesawat

Suatu **polimer** adalah rantai berulang dari atom yang panjang, terbentuk dari pengikat yang berupa molekul identik yang disebut monomer. Sekalipun biasanya merupakan organik (memiliki rantai karbon), ada juga banyak polimer inorganik. Contoh terkenal dari polimer adalah plastik dan DNA.

Sekilas

Meskipun istilah polimer lebih populer menunjuk kepada plastik, tetapi polimer sebenarnya terdiri dari banyak kelas

material alami dan sintetik dengan sifat dan kegunaan yang beragam. Bahan polimer alami seperti shellac dan amber telah digunakan selama beberapa abad. Kertas diproduksi dari selulosa, sebuah polisakarida yang terjadi secara alami yang ditemukan dalam tumbuhan. Biopolimer seperti protein dan asam nukleat memainkan peranan penting dalam proses biologi.

[sunting] Klasifikasi polimer

[sunting] Berdasarkan sumbernya

1. Polimer alami : kayu, kulit binatang, kapas, karet alam, rambut
2. Polimer sintetis
    1. Tidak terdapat secara alami: nylon, poliester, polipropilen, polistiren
    2. Terdapat di alam tetapi dibuat oleh proses buatan: karet sintetis
    3. Polimer alami yang dimodifikasi: seluloid, cellophane (bahan dasarnya dari selulosa tetapi telah mengalami modifikasi secara radikal sehingga kehilangan sifat-sifat kimia dan fisika asalnya)

[sunting] Berdasarkan jumlah rantai karbonnya

1. 1 ~ 4 Gas (LPG, LNG)
2. 5 ~ 11 Cair (bensin)
3. 9 ~ 16 Cairan dengan viskositas rendah
4. 16 ~ 25 Cairan dengan viskositas tinggi (oli, gemuk)
5. 25 ~ 30 Padat (parafin, lilin)
6. 1000 ~ 3000 Plastik (polistiren, polietilen, dll)

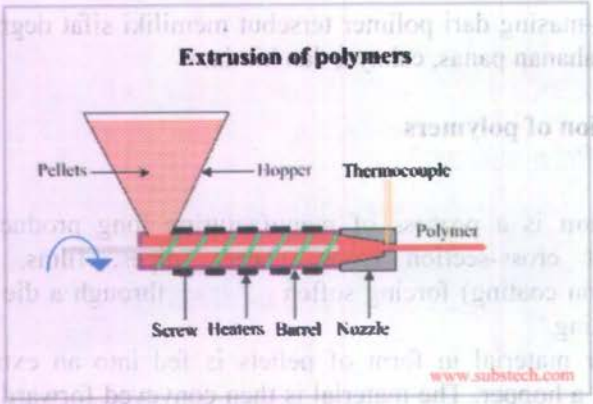
[sunting] Industri

Sekarang ini utamanya ada enam komoditas polimer yang banyak digunakan, mereka adalah polyethylene, polypropylene, polyvinyl chloride, polyethylene terephthalate, polystyrene, dan polycarbonate. Mereka membentuk 98% dari seluruh polimer dan plastik yang ditemukan dalam kehidupan sehari-hari.

Masing-masing dari polimer tersebut memiliki sifat degradasi dan ketahanan panas, cahaya, dan kimia.

Extrusion of polymers
Dr. Dmitri Kopeliovich

Extrusion is a process of manufacturing long products of constant cross-section (rods, sheets, pipes, films, wire insulation coating) forcing soften polymer through a die with an opening.
Polymer material in form of pellets is fed into an extruder through a hopper. The material is then conveyed forward by a feeding screw and forced through a die, converting to continuous polymer product.
Heating elements, placed over the barrel, soften and melt the polymer. The temperature of the material is controlled by thermocouples.
The product going out of the die is cooled by blown air or in water bath.
Extrusion of polymers (in contrast to extrusion of metals) is continuous process lasting as long as raw pellets are supplied.
Extrusion is used mainly for Thermoplastics, but Elastomers and Thermosets are also may be extruded. In this case cross-linking forms during heating and melting of the material in the extruder.
The thermoplastic extruded products may be further formed by the Thermoforming method.
A principal scheme of an extruder is shown in the picture.



Thermoplastic Low Density Polyethylene (LDPE)
(submitted by the website administration)

Thermoplastic

Low Density Polyethylene (LDPE)

Property	Value in metric unit		Value in US unit	
Density	0.92 *10³	kg/m³	57.4	lb/ft³
Modulus of elasticity	0.29	GPa	42	ksi
Tensile strength	17	MPa	2500	psi
Elongation	500	%	500	%
Flexural strength	14	MPa	2000	psi
Thermal expansion (20 °C)	$16*10^{-5}$	°C⁻¹	$9*10^{-5}$	in/(in* °F)
Thermal conductivity	0.33	W/(m*K)	2.29	BTU*in/(hr*ft²*°F)

Melting point	120	°C	248	°F
Maximum work temperature	90	°C	194	°F
Electric resistivity	10^{13}-10^{16}	Ohm*m	10^{15}-10^{18}	Ohm*cm
Dielectric constant	2.3	-	2.3	-

- Good impact strength;
- Good chemical resistance;
- Good flexibility;
- Poor UV resistance;
- Good hot formability.

Applications: packaging films (general purpose, shrink, lamination), containers, cable insulation, chemically resistant linings.

Thermoplastic High Density Polyethylene (HDPE)
(submitted by the website administration)

Thermoplastic

High Density Polyethylene (HDPE)

Property	**Value in metric unit**		**Value in US unit**	
Density	$0.95*10^3$	kg/m^3	59.3	lb/ft^3
Modulus of elasticity	1.86	GPa	270	ksi
Tensile strength	31	MPa	4500	psi
Elongation	100	%	100	%
Flexural strength	40	MPa	5800	psi
Thermal	$12.6*10^{-}$	$°C^{-1}$	$7*10^{-}$	in/(in* °F)

expansion (20 °C)	5		5	
Thermal conductivity	0.48	W/(m*K)	3.33	BTU*in/(hr*ft²*°F)
Melting point	130	°C	266	°F
Maximum work temperature	120	°C	248	°F
Electric resistivity	10^{13}-10^{16}	Ohm*m	10^{15}-10^{18}	Ohm*cm
Dielectric constant	2.4	-	2.4	-

- Goog strength;
- Good impact strength;
- Good chemical resistance;
- Good stiffness;
- Poor UV resistance.

Applications: packaging films, heavy duty shrink film, pipes, containers, bags, blown bottles.

Thermoplastic Polypropylene (PP)
(submitted by the website administration)

Thermoplastic Polypropylene (PP)

Property	**Value in metric unit**		**Value in US unit**	
Density	0.91 *10³	kg/m³	56.8	lb/ft³
Modulus of elasticity	1.36	GPa	195	ksi
Tensile strength	37	MPa	5300	psi

Elongation	350	%	350	%
Flexural strength	49	MPa	7000	psi
Thermal expansion (20 °C)	$90*10^{-6}$	$°C^{-1}$	$50*10^{-6}$	in/(in* °F)
Thermal conductivity	0.16	W/(m*K)	1.11	BTU*in/(hr*ft²*°F)
Glass transition temperature	-10	°C	14	°F
Maximum work temperature	150	°C	302	°F
Electric resistivity	10^7 - 10^9	Ohm*m	10^9 - 10^{11}	Ohm*cm
Dielectric constant	2.4	-	2.4	-

- Good chemical resistance;
- Good fatigue resistance;
- Good heat resistance.

Applications: packaging, ventilators, boxes of TV and radio sets, toys, furniture components, bumpers.

Polymer is a substance (natural or synthetic), molecules of which consist of numerous small repeated chemical units (**monomers**) linked to each other in a regular pattern.

Polymers usually combine crystalline and amorphous structures (semi-crystalline).

Degree of polymerization is an average number of monomers (mers) in a polymer molecule.

Polymer molecules may combine up to million of monomers (mers) forming a one-dimensional structure (chain), two-

dimensional structure (planar molecules) or three-dimensional structure.

One-dimensional structure is common for organic polymers.

Organic polymer is a polymer compound built of hydrocarbon base monomer units.

Besides carbon and Hydrogen the following atoms may be incorporated in polymer molecules: Oxygen, Nitrogen, chorine, fluorine, silicon, phosphorous, and sulfur.

Atoms of a polymer molecule are held by covalent bonding.

Neighboring chains may form secondary bonds between them (**cross-links**) which are less strong than covalent bonding between the atoms within the molecules.

Cross-links provide elasticity to the polymer, preventing sliding of the neighboring chains when the material is stretched.

Branched polymer consists of molecules having side chains (branches) attached to the main chain.

Copolymer is a polymer molecule of which contains more than one kind of monomers.

Nylon is a common copolymer. Its molecules consist of two alternating monomers: diacid and diamine.

Graft copolymer is a kind of branch polymer, side chains of which are made of monomers differing from the monomer of the main chain.

Block copolymer is a polymer molecules of which built from alternating polymeric blocks of two or more different polymers.

Structure parameters affecting polymer properties:

- Increase of the chain length.

Effect: increase of tensile strength and Modulus of Elasticity (stiffness).

- Increase of number and length of side chains.

Effect: increase of tensile strength and stiffness.

- Introduction of large monomers in molecules.

Effect: increase of stiffness.

- Increase of number and strength of cross-links.

Effect: increase of tensile strength and stiffness.

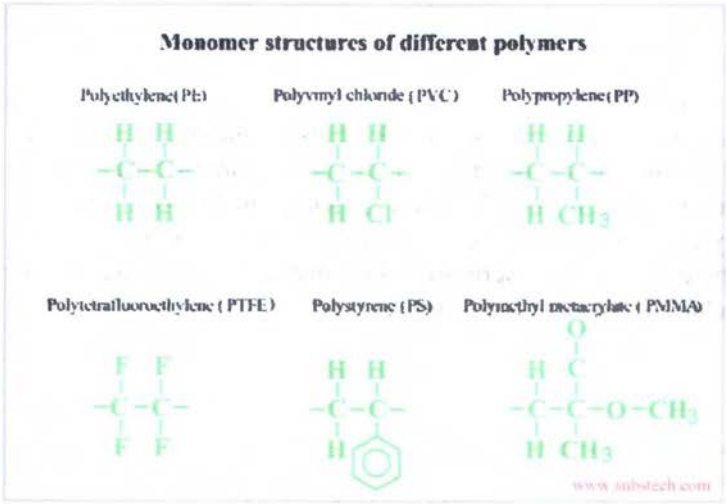
- Orientation of the molecules as a result of deformation during manufacturing.

Effect: anisotropy of the material properties (properties along the deformation differ from those in other directions).

Every polymer is characterized by a temperature below of which mobility of its molecules sharply decreases and the material becomes brittle and glassy.

This temperature is called **Glass Transition Temperature**.

Monomer molecular structures of different polymers are presented in the picture:



Thermoforming

Dr. Dmitri Kopeliovich

Thermoforming is a process of shaping flat thermoplastic sheet which includes two stages: softening the sheet by heating, followed by forming it in the mold cavity.

Elastomers and Thermosets can not be formed by the Thermoforming methods because of their cross-linked structure – they do not soften when heated.

Thermoplastics which may be processed by the thermoforming method are:

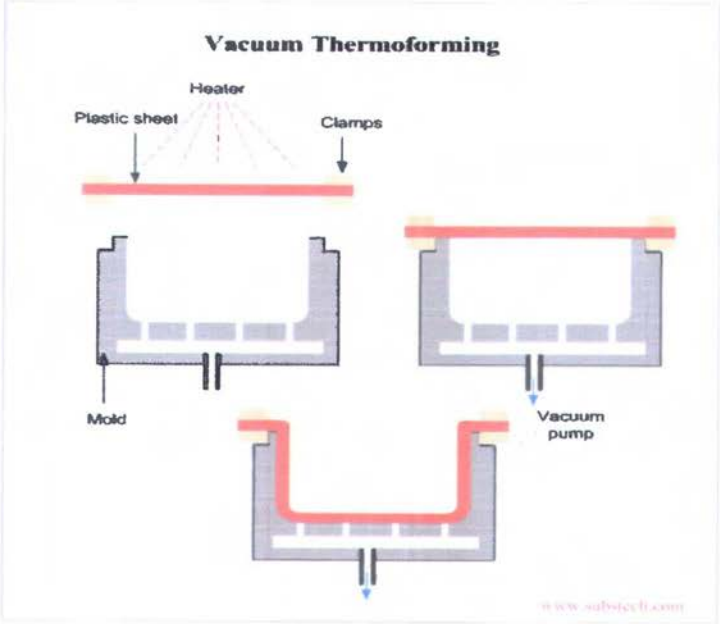
- Polypropylene (PP)
- Polystyrene (PS)
- Polyvinyl Chloride (PVC)
- Low Density Polyethylene (LDPE)
- High Density Polyethylene (HDPE)
- Cellulose Acetate
- Polymethylmethacrylate (PMMA)
- Acrylonitrile-Butadiene-Styrene (ABS)

Thermoforming is widely used in the food packaging industry for manufacturing ice cream and margarine tubs, meat trays microwave containers, snack tubs sandwich packs etc. Thermoforming is also used for manufacturing some pharmaceutical and electronic articles, small tools, fasteners, toys, boat hulls, blister and skin packs.
There are three thermoforming methods, differing in the technique used for the forming stage:

- **Vacuum Thermoforming**
- **Pressure Thermoforming**
- **Mechanical Thermoforming**

Vacuum Thermoforming

The process involves shaping a preheated thermoplastic sheet by means of vacuum produced in the mold cavity space.
The atmospheric pressure forces the soft sheet to deform in conformity with the cavity shape.
When the plastic comes into the contact with the mold surface it cools down and hardens.



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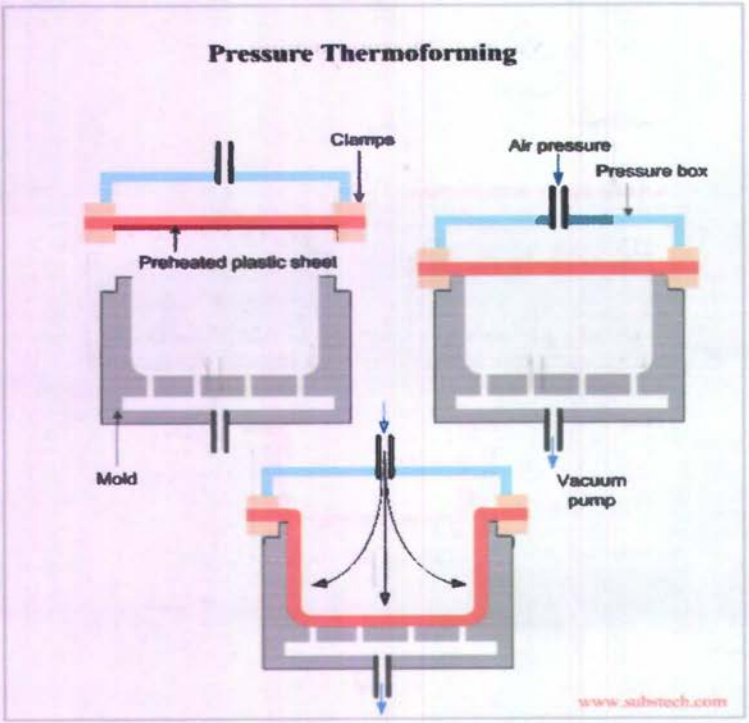
Pressure Thermoforming

The process involves shaping a preheated thermoplastic sheet by means of air pressure.

The air pressure forces the soft sheet to deform in conformity with the cavity shape.

When the plastic comes into the contact with the mold surface it cools down and hardens.



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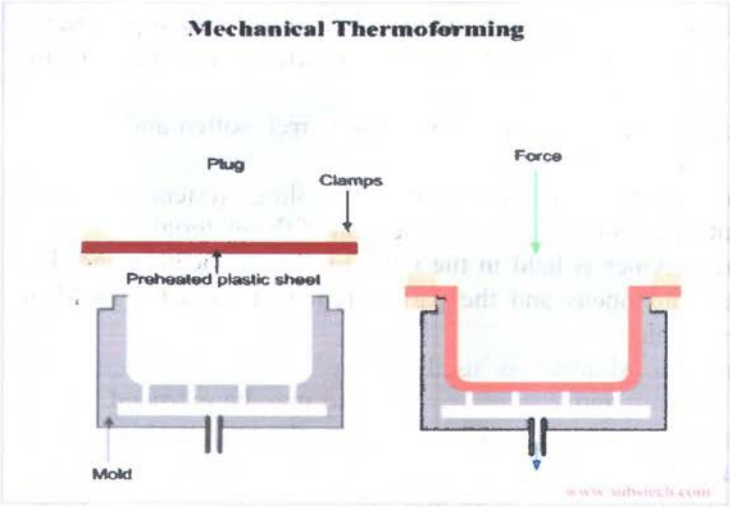
Mechanical Thermoforming

The process involves shaping a preheated thermoplastic sheet by means of a direct mechanical force.

A core plug (positive mold) forces the soft sheet to fill the space between the plug and the negative mold.

The process provides precise dimensional tolerance and surface detailing.



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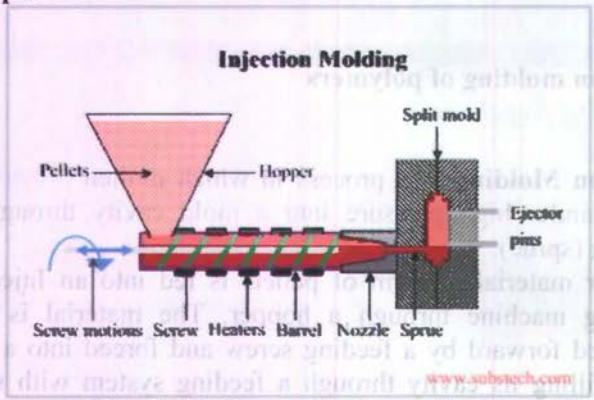
Injection molding of polymers
Dr. Dmitri Kopeliovich

Injection Molding is a process in which molten polymer is forced under high pressure into a mold cavity through an opening (sprue).
Polymer material in form of pellets is fed into an Injection Molding machine through a hopper. The material is then conveyed forward by a feeding screw and forced into a split mold, filling its cavity through a feeding system with sprue gate and runners.
Injection Molding machine is similar to Extruder. The main difference between the two machines is in screw operation. In extruder screw rotates continuously providing output of continuous long product (pipe, rod, sheet). Screw of injection molding machine is called reciprocating screw since it not only rotates but also moves forward and backward according to the steps of the molding cycle.

It acts as a ram in the filling step when the molten polymer is injected into the mold and then it retracts backward in the molding step.
Heating elements, placed over the barrel, soften and melt the polymer.
The mold is equipped with a cooling system providing controlled cooling and solidification of the material.
The polymer is held in the mold until solidification and then the mold opens and the part is removed from the mold by ejector pins.
Injection Molding is used mainly for Thermoplastics, but Elastomers and Thermosets are also may be extruded. In this case cross-linking occurs during heating and melting of the material in the heated barrel.
A principal scheme of an Injection Molding Machine is shown in the picture.



Injection Molding is highly productive method providing high accuracy and control of shape of the manufactured parts. The method is profitable in mass production of large number of identical parts.
Thermoplastics commonly used in Injection Molding are as follows:

- Polypropylene (PP)
- Polycarbonate (PC)

- Acrylonitrile-Butadiene-Styrene (ABS)
- Nylon 6 (N6)

Injection Molding is used for manufacturing DVDs, pipe fittings, battery casings, toothbrush bases, bottle lids, disposable razors, automobile bumpers and dash boards, power-tool housing, television cabinets, electrical switches, telephone handsets, automotive power brake, automotive fascias, transmission, and electrical parts, mirror housings, steam irons, washer pumps, spoilers, butter tubs, moisture vaporizers, yogurt containers, toilet seats, cell-phone housings, cradles or bases for personal digital assistants, case of a notebook-computer, computer mouse, electrical connector housings, lawn chairs, automotive ashtrays, and cookware appliance handles and knobs, aerosol caps, household items, bottle caps, toys.

Blow molding
Dr. Dmitri Kopeliovich

Blow Molding is a process in which a heated hollow thermoplastic tube **(parison)** is inflated into a closed mold conforming the shape of the mold cavity.

The most widely used materials for Blow Molding are:

- Low Density Polyethylene (LDPE), High Density Polyethylene (HDPE)
- Polypropylene (PP)
- Polyvinyl Chloride (PVC)
- Polyethylene Terephtalate (PET)

Disposable containers of various sizes and shapes, drums, recyclable bottles, automotive fuel tanks, storage tanks, globe light fixtures, toys, tubs, small boats are produced by Blow Molding method.

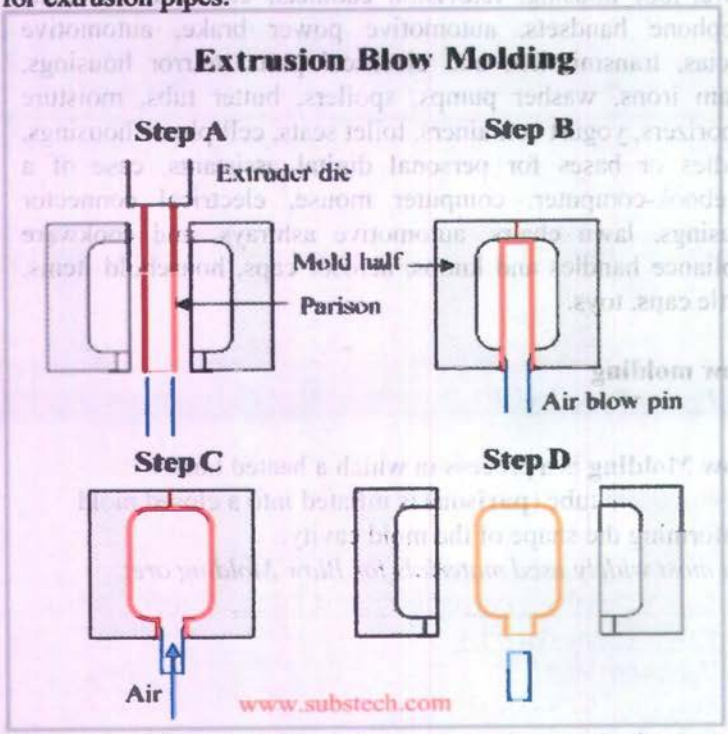
There are three principal techniques of Blow Molding, differing in the method by which parisons are prepared:

- **Extrusion Blow Molding**

- Injection Blow Molding
- Stretch Blow Molding

Extrusion Blow Molding

Extrusion Blow Molding involves manufacture of parison by conventional extrusion method using a die similar to that used for extrusion pipes.



Extrusion Blow Molding is commonly used for mass production of plastic bottles.

The production cycle consists of the following steps:

- The parison is extruded vertically in downward direction between two mold halves.
- When the parison reaches the required length the two mold halves close resulting in pinching the top of parison

end and sealing the blow pin in the bottom of the parison end.

- Parison is inflated by air blown through the blow pin, taking a shape conforming that of the mold cavity. The parison is then cut on the top.
- The mold cools down, its halves open, and the final part is removed.

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Injection Blow Molding

In Injection Blow Molding method a parison is produced by injecting a polymer into a hot injection mold around a blow tube or core rod.

Then the blow tube together with the parison is removed from the injection mold and transferred to a blow mold.

Following operations are similar to those in the extrusion blowing molding.

Injection Blow Molding is more accurate and controllable process as compared to the Extrusion Blow Molding.

It allows producing more complicated products from a wider range of polymer materials.

However production rate of Injection Blow Molding method is lower than that of Extrusion Blow Molding.

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Stretch Blow Molding

Stretch Blow Molding is similar to Injection Plow Molding.

Stretch Blow Molding involves injection molding of a parison, which is then stretched in the downward direction by means of the blow tube.

The extended parison is then inflated in a blow mold.

In this method biaxial molecular orientation is produced. The specific molecular orientation provides higher mechanical strength, rigidity and transparency of the material.

Material, commonly used in this method is Polyethylene Terephtalate (PET).

Stretch Blow Molding is used for manufacturing containers for carbonated beverages.

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Compression molding of polymers

Dr. Dmitri Kopeliovich

Compression Molding is a process in which a molding polymer is squeezed into a preheated mold taking a shape of the mold cavity and performing curing due to heat and pressure applied to the material.

The method is used mostly for molding thermosetting resins (thermosets), but some thermoplastic parts may also be produced by Compression Molding.

The method uses a split mold mounted in a hydraulic press

Compression Molding process involves the following steps:

- A pre-weighed amount of a polymer mixed with additives and fillers (charge) is placed into the lower half of the mold.

The charge may be in form of powders, pellets, putty-like masses or pre-formed blanks.

The charge is usually preheated prior to placement into the mold. Preheated polymer becomes softer resulting in shortening the molding cycle time.

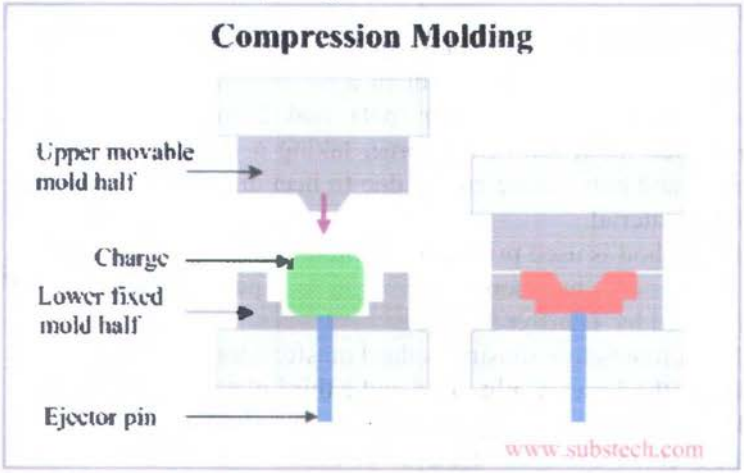
- The upper half of the mold moves downwards, pressing on the polymer charge and forcing it to fill the mold cavity.

The mold, equipped with a heating system, provides curing (cross-linking) of the polymer (if thermoset is processed).

- The mold is opened and the part is removed from it by means of the ejector pin.

If thermosetting resin is molded, the mold may be open in hot state – cured thermosets maintain their shape and dimensions even in hot state.

If thermoplastic is molded, the mold and the molded part are cooled down before opening.



Compression Molding cycle time is about 1-6 min, which is longer than Injection Molding cycle.

The method is suitable for molding large flat or moderately curved parts.

Materials commonly processed by Compression Molding are:

- Epoxies (EP)
- Urea Formaldehyde (UF)
- Melamine Formaldehyde (MF)
- Phenolics (PF)

Compression Molding is used for manufacturing electrical wall receptacles, brush and mirror handles, meter cases, trays, circuit breakers, cookware knobs, clothes dryer blower fan blade, electronic and cooking utensils, milling machine adjustment wheel, automotive parts, water testing equipment buttons, television cabinets, dinnerware, appliance housings, radio cases, aircraft main power terminal housing, hoods, pot handles, spoilers, electric plugs and sockets, fenders, dinnerware plates, scoops.

Transfer molding of polymers
Dr. Dmitri Kopeliovich

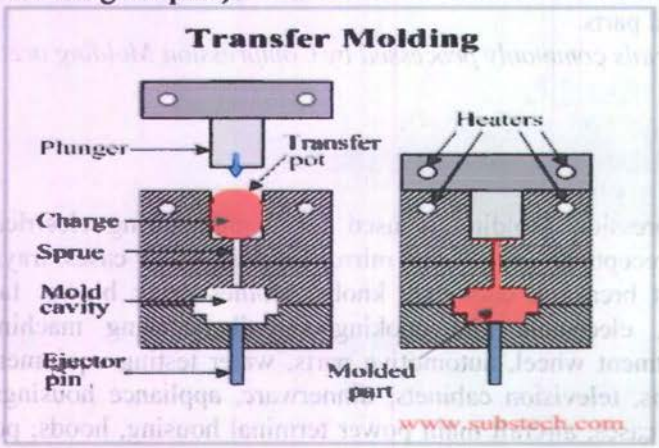
Transfer Molding (Resin Transfer Molding) is a process in which a pre-weighed amount of a polymer is preheated in a separate chamber (transfer pot) and then forced into a preheated mold through a sprue, taking a shape of the mold cavity and performing curing due to heat and pressure applied to the material.

The method is used primarily for molding thermosetting resins (thermosets), but some thermoplastic parts may also be produced by Transfer Molding.

The picture below illustrates the Transfer Molding Process.

The method uses a split mold and a third plate equipped with a plunger mounted in a hydraulic press.

The method combines features of both Compression Molding (hydraulic pressing and the same molding materials - thermosets) and Injection Molding (ram-plunger and filling the mold through a sprue).



Transfer Molding process involves the following steps:

- A pre-weighed amount of a polymer mixed with additives and fillers (charge) is placed into the transfer pot.

The charge may be in form of powders, pellets, putty-like masses or pre-formed blanks.
The charge is heated in the pot where the polymer softens.

- The plunger, mounted on the top plate, moves downwards, pressing on the polymer charge and forcing it to fill the mold cavity through the sprue.

The mold, equipped with a heating system, provides curing (cross-linking) of the polymer (if thermoset is processed).

- The mold is opened and the part is removed from it by means of the ejector pin.

If thermosetting resin is molded, the mold may be open in hot state – cured thermosets maintain their shape and dimensions even in hot state.
If thermoplastic is molded, the mold and the molded part are cooled down before opening.

- The scrap left on the pot bottom (cull), in the sprue and in the channels is removed. Scrap of thermosetting polymers is not recyclable.

Transfer Molding cycle time is shorter than Compression Molding cycle but longer than Injection Molding cycle.
The method is capable to produce more complicated shapes than Compression Molding but not as complicated as Injection Molding.
Transfer Molding is suitable for molding with ceramic or metallic inserts which are placed in the mold cavity. When the heated polymer fills the mold it forms bonding with the insert surface.

Transfer molding of thermosets is used for molding parts encapsulating metal inserts, wear plates, pins, studs, electronic components with molded terminals. Transfer molding is also used for manufacturing radio and television cabinets and car body shells.

Materials commonly processed by Compression Molding are:

- Epoxies (EP)
- Unsaturated Polyesters (UP)
- Phenolics (PF)
- Vinylester

Table Of Contents

10 section

Tubular Heaters

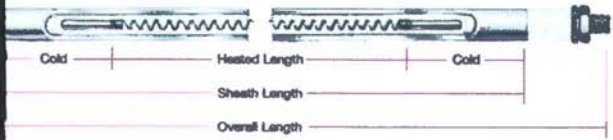
Tubular Heater Introduction

plications

- *heating*
- *orming machines*
- *nersion in liquids*
- *adiant heaters*
- *razed or clamped to tanks and pipes*
- *r molds*
- *ion radiant and convection heater for dryers*

Construction Characteristics

Tempco Tubular Heaters are the most versatile and widely used source of electric heat for industrial, commercial and scientific applications. They can be designed in a wide range of electrical ratings, diameters, lengths, terminations, and sheath materials. Important and useful characteristics of tubular heaters are that they can be formed into virtually any shape, brazed or welded to any metal surface, and cast into metals. Carefully researched manufacturing methods and quality materials have made Tempco tubular heaters stand apart from other heating elements claiming similar performance.



The cut-away view shows the tubular heater's basic construction. A computer-designed helical coil of 80% Nickel 20% Chromium alloy resistance wire is fusion welded to the nickel-coated steel terminal cold pin. This coil assembly is precisely stretched and centered in the element metal sheath, which is then filled with Grade "A" Magnesium Oxide powder (MgO). The filled tube is then compacted by a roll reduction mill into a solid mass, permanently stabilizing the coil in the center of the tube while providing excellent heat transfer and dielectric strength between the coil and the sheath.

Design Guidelines

Tolerance

ing elements have an Industry Standard Resistance +10%, –5% which translates to a Wattage Tolerance %. Consult Tempco if tighter tolerances are required ication.

ty

t Density is the wattage dissipated per square inch of heath surface and is critical to the proper heating of the nd to the life expectancy of the heater. The Watt Density with the following formula:

$$(w/in^2) = \frac{\text{Element Wattage}}{\pi \times \text{Element Dia.} \times \text{Element Heated Length}}$$

ar application element watt density will govern element ternal resistance wire temperature. Factors to consider g a suitable watt density are:

erials are heat sensitive and can decompose or be damelement is running too hot.

her gases that are poor conductors of heat require watt natched to the velocity of the gas flow to prevent element g.

ing hard water or cleaning solutions mineral deposits up on the element sheath, acting as a heat insulator and internal element temperature. If these deposits cannot ally removed, use a lower watt density element to increase expectancy.

2 in the Engineering Data Section of this catalog lists the recommended heater watt density for many materials. nal information and help please contact Tempco.

rtant Note — When heating any substance it is critical tch the heater watt density, operating temperature and sheath ial to the specific medium being heated. Failure to do so will in premature heater failure and/or unsafe conditions.

Agency Approvals

Tempco Tubular Heating Elements have been certified as Recognized Components by Underwriters Laboratories (File Number E90771) under Classification UBJY2 after testing to meet Standard UL1030. Tempco's equivalent CSA File number is LR43099-5.

These files specify the Watt Density limitation per application type and any other limitations imposed by these agencies in the use of this type of heater. For additional information consult Tempco.

If you require UL and/or CSA approval please specify when ordering.

Tubular Heater Standard Specifications

Element Diameter in	Element Diameter mm	Maximum Voltage	Maximum Amperage	Resistance in Ohms per Heated Inch min	Resistance in Ohms per Heated Inch max	Sheath Length min in	Sheath Length min mm	Sheath Length max in	Sheath Length max mm
60	6.6	250	15	.100	17	11	279	200	5080
15	8.0	480	30	.060	21	11	279	200	5080
75	9.5	600	30	.040	21	11	279	200	5080
30	10.9	600	40	.040	21	11	279	268	6807
75	12.1	600	40	.040	21	11	279	200	5080
25	15.9	600	40	.040	17	11	279	255	6477

Table 1 Electrical Limitations and Minimum/Maximum Sheath Lengths

Length in	Length mm	Sheath Length Tolerance (±) in	Sheath Length Tolerance (±) mm	Heated Length Tolerance (±) in	Heated Length Tolerance (±) mm	Minimum Unheated Length Each End in	Minimum Unheated Length Each End mm
1-20	279-508	3/32	2.4	1/4	6	1	25
0-50	508-1270	1/8	3.2	1/2	13	1-1/4	32
0-80	1270-2032	5/32	4.0	7/8	22	1-1/2	38
0-110	2032-2794	3/16	4.8	1-1/8	29	1-5/8	42
0-140	2794-3556	7/32	5.6	1-3/8	35	1-3/4	44
0-170	3556-4318	1/4	6.4	1-5/8	41	2	51
0-200	4318-5080	3/8	9.5	1-7/8	48	2-1/4	57
0-up	5080-up	1/2	12.7	2-3/8	60	2-1/2	64

Table 2 Sheath and Heated Length Tolerance (applicable for all diameters)

Tubular Heater Standard Sheath Materials

lection of a sheath material should be made based on the the chemical composition of the gas or liquid being heated, the charac-cs of the materials entering the solution, and the processes controls. A material selection guide can be found on page 16-12.

The best source for chemical/sheath compatibility is the supplier of the gas or liquid to be heated.

The following are the most common tubular element sheath materials. For other materials consult Tempco.

oy® 840: Nickel 18-20%, Chromium 18-22%, Iron balance. bout 10% less nickel than Incoloy 800. Used in many air g applications where it has exhibited superior oxidation nce at less cost than Incoloy 800.
mum Sheath Temperature: 1600°F / 871°C

oy® 800: Nickel 30-35%, Chromium 19-23%, Iron balance. igh nickel content of this alloy contributes to its resistance aling and corrosion. Used in air heating and immersion g of potable water and other liquids.
mum Sheath Temperature: 1600°F / 871°C

tainless Steel: Chromium 16-18%, Nickel 11-14%, Iron ce. Modified with the addition of Molybdenum (2-3%) to ve corrosion resistance in certain environments, especially which would tend to cause pitting due to the presence of des. Applications include deionized water.
mum Sheath Temperature: 1200°F / 649°C

tainless Steel: Chromium 18-20%, Nickel 8-11%, Iron ce. Used in the food industry, medical, and chemical heating.
mum Sheath Temperature: 1200°F / 649°C

tainless Steel: Chromium 17-20%, Nickel 9-13%, Iron ce. Modified with the addition of Titanium to prevent le precipitation and resulting intergranular corrosion that can place in certain mediums when operating in the 800-1200°F 549°C) temperature range.
mum Sheath Temperature: 1200°F / 649°C

Copper: Standard Copper Alloy

A low temperature, inexpensive material used mainly for clean water heating.
Maximum Sheath Temperature: 350°F / 177°C

Steel: Low Carbon

Used for high to low viscosity oils, asphalt, tar, wax, molten salt, heat transfer liquid media and other compatible solutions.
Maximum Sheath Temperature: 750°F / 399°C

Other Sheath Materials Available for a limited number of diameters. Consult Tempco for more information.

Inconel® 600: Iron 6-10%, Chromium 14-17%, Nickel balance
Maximum Sheath Temperature: 1800°F / 982°C

Incoloy® 825: Nickel 38-46%, Chromium 19.5-23.5%, Molybdenum 2.5-3.5%, Iron balance
Maximum Sheath Temperature: 1600°F / 871°C

CAUTION

Maximum Sheath Temperature refers to the maximum temperature of the element sheath material. ***Consideration must be given to the maximum temperature that can be safely applied to the heated material.*** See Watt Density on the previous page for additional information.

Treatments and Terminations

Incoloy® and Stainless Steel Element Sheath Surface Treatments

urface Finish

d tubular heater element surface finish is a black le, produced when the element is annealed prior to n exothermic atmosphere furnace.

urface Finishes

ealing is an option where the tubular heater is dissociated ammonia atmosphere furnace. This pro- n metallic appearance without surface etching the

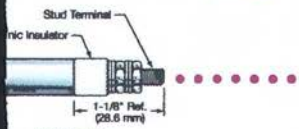
Electro-Polishing is an electrochemical process that removes surface imperfections and contaminants, enhancing the corrosion resisting ability of the sheath. The resulting surface is clean, smooth and has a bright finish; it is highly recommended for medical, food and other harsh applications.

Passivation removes surface contamination, usually iron, so that the optimum corrosion resistance of the stainless steel is maintained. Surface contamination could come from the small amount of steel that may be worn off a tool during the manufacturing process.

Standard Tubular Heater Terminations

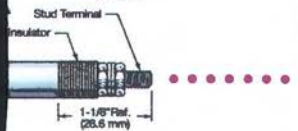
Select the termination style that meets your requirements for space, accessibility and reliability.

Note: If the listed terminations do not seem to fit your requirements, call us and let us design one that will.



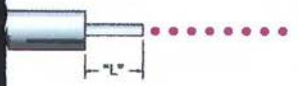
TYPE T—STANDARD

Threaded stud terminal with ceramic insulator. Standard thread size is 6-32 for .260" (6.6 mm), 8-32 for .315" (8 mm), .335" (8.5 mm) and .375" (9.5 mm), and 10-32 for all other diameters. Other thread sizes and lengths are available to accommodate any electrical requirements and clearance restrictions.



TYPE TM—Stud with Mica Insulator

Stud terminal with mica insulator. Standard thread size is 6-32 for .260" (6.6 mm), 8-32 for .315" (8 mm), .335" (8.5 mm) and .375" (9.5 mm), and 10-32 for all other diameters. Other thread sizes and lengths are available to accommodate any electrical requirements and clearance restrictions.

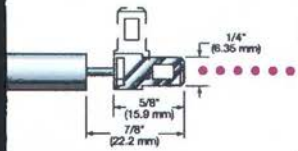


TYPE P—Plain Pin

Plain terminal pin. Specify Length "L"

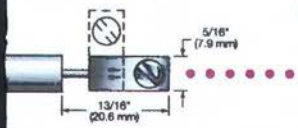
Standard 1/2" (12.7 mm) pin length.

Element Diameter		Nominal Pin Diameter	
in	mm	in	mm
.260	6.6	.091	2.3
.315	8.0	.105	2.7
.375	9.5	.105	2.7
.430	10.9	.125	3.2
.475	12.0	.125	3.2
.625	15.9	.160	4.1



TYPE SF & SF9 (90°)—Quick Connect

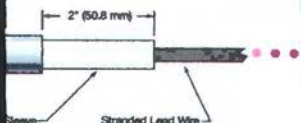
1/4" male quick connect (slip-on) terminals are welded to the element terminal pin. They provide quick and easy installation of lead wire with excellent holding force. Material: Nickel-Plated Steel.



TYPE L__ & L9__ (90°)—Terminal Lug

A nickel-plated steel lug is projection welded to the terminal pin straight (Type "L_") or at 90° to the sheath (Type "L9_").

Standard LA, L9A 10-32 screw
Optional LB, L9B 8-32 screw



TYPE F1__—Lead Wire

Type F1A Type TGGT (Teflon® tape, fiberglass, Teflon® treated overbraid) insulation rated to 482°F (250°C).

Type F1B Type MGT (mica tape, Teflon® treated overbraid) insulation rated to 842°F (450°C).

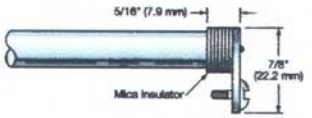
Standard 10" (254 mm) leads. Specify longer leads if required.

Lead wire gauge is determined by the ampacity of the heater with the lead wires in an ambient temperature of 40°C (104°F). Higher ambients may require heavier gauge lead wires.

Tubular Heater Standard Terminations

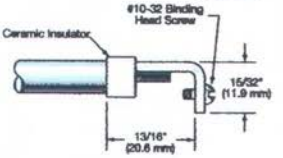
TYPE E—Right-Angle Lug Terminal

A solid termination that reinforces the pin with a mica insulator
Standard 8-32 screw



TYPE A—Right-Angle Terminal

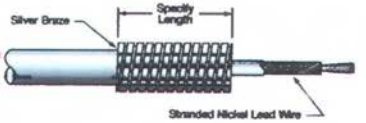
A good screw style termination for use when space is tight
Standard 10-32 screw



TYPE R1__—Flexible Armor Cable

Type R1A Galvanized cable
Type R1B Stainless steel cable

Provides excellent protection to lead wires in abrasive environments.
Specify cable length and lead wire length.
Standard 10" (254 mm) armor cable over 12" (305 mm) leads.
Specify longer leads or cable, if required.

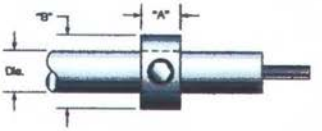


Tubular Heater Standard Mounting Methods

Number	For Element Diameter in	For Element Diameter mm	"A" THK in	"A" THK mm	"B" OD in	"B" OD mm
-108-102	.260	6.6	5/16	7.9	5/8	15.9
-108-102	.315	8.0	5/16	7.9	5/8	15.9
-108-103	.375	9.5	3/8	9.5	3/4	19.1
-108-104	.430	10.9	7/16	11.1	7/8	22.2
108-106	.475	12.0	7/16	11.1	1	25.4

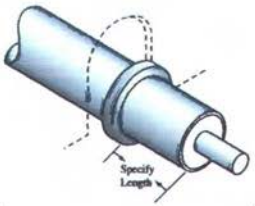
TYPE MC — Mounting Collar

Plated steel mounting collars are locked in place with a set-screw and serve as an adjustable stop for through-the-wall mounting. Collars are shipped in bulk unless otherwise specified. Mounting collars can be ordered with the heater or purchased separately.



YPE LR — Locator Washer

ocator washers are permanently attached to the heater sheath by staking/crimping nd are used to limit the movement of the heater while allowing for expansion and ontraction of the heater sheath. When ordering, specify location from end of sheath.



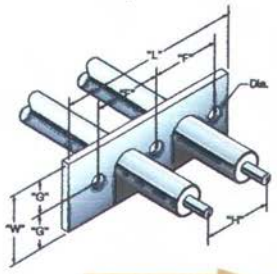
le element heater bly with a custom ing bracket.

TYPE MF — Mounting Bracket

Tempco's made-to-order mounting brackets are made from 18 gauge stainless steel for strength and stiffness. It is an economical way to mount the heater in non-pressurizing, non-liquid applications. Unless otherwise specified, the bracket will be located 1/2" from the edge of the heater sheath. OEM quantity brackets are manufactured by Tempco on our own high speed precision N/C Turret Press. The standard method of attaching the tubular element to the bracket is staking or crimping.

The rectangular mounting bracket shown at right is a popular, made-to-order design. Specify all dimensions shown when requesting a quote.

Custom brackets of any size, thickness or material can be supplied to meet your requirements.



CONTINUED

Tubular Heater Standard Mounting Methods

om previous page...

Bulkhead Fittings

ittings provide a leak-proof method for mounting g elements through tank walls. Brass crimped fittings low pressure water (up to 80 psig) or non-pressure stainless steel jam nut and washer are required when less steel fittings. Brass hex nut, plated steel washer e standard.

vacuum or high pressure gas and liquid use are silver G welded. Method will vary by material and applica- in table are most commonly used. Special fittings can eet your application requirements.

Standard fitting location is with threads flush at the end of the element sheath as shown below. For other locations specify distance from end of sheath.

Do not locate the fitting over the heated section of the element.

Specify: Material; Round or Hex Flange; Thread Type and Length; Location on Sheath; Crimped, Brazed, or Welded Construction.

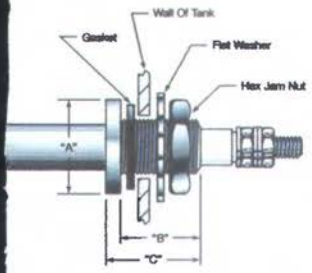
Fitting Attachment Method — General Guidelines

idelines only. ***Consult Tempco if you require assistance in determining the method best suited for your application.***

Fittings Crimped: Low pressure water (up to 80 psig) and non-pressure air applications

Fittings Brazed: Non-ferrous alloys (copper) and dissimilar non-weldable metals

Fittings Welded: High pressure liquids and gases, and high temperature applications



Standard Bulkhead Fittings For Tubular Heaters — Round Flanged Standard

Tubular Diameter in	Tubular Diameter mm	Fitting Material	Flange Type	"A" in	"A" mm	"B" in	"B" mm	"C" in	"C" mm	Thread Size (UNF)
.260	6.6	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.260	6.6	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.315	8.0	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.315	8.0	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.375	9.5	Brass	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.375	9.5	Stn. Stl.	Round	3/4	19	1/2	12.7	5/8	16	1/2-20
.430	10.9	Brass	Round or Hex	7/8	22	3/4	19.0	7/8	22	5/8-18
.430	10.9	Stn. Stl.	Round or Hex	7/8	22	3/4	19.0	7/8	22	5/8-18
.430	10.9	Steel	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Brass	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Stn. Stl.	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Steel	Round	7/8	22	3/4	19.0	7/8	22	5/8-18
.475	12.1	Brass	Round	1	25	3/4	19.0	7/8	22	3/4-16
.475	12.1	Stn. Stl.	Round	1	25	3/4	19.0	7/8	22	3/4-16
.625	15.9	Stn. Stl.	Round	1-1/8	29	3/4	19.0	1	25	7/8-14

Optional: Hex Flanged Bulkhead Fittings. Specify if required.

Tubular Heater Standard Moisture Seals

nesium Oxide (MgO) is used as the insulating material in pco tubular heaters because of its excellent thermal conduc- and dielectric strength. However, MgO is hygroscopic and bsorb moisture from the atmosphere. This absorption of ture may be detected when an Insulation Resistance (IR) test e with a megohmmeter prior to energizing the heater circuit. y humid environments, circuits utilizing a GFI (ground fault upter) for safety may experience nuisance tripping when izing the heater.

Tempco manufacturing process produces a dry element with of several thousand megohms minimum. However, after ent and depending on humidity levels and storage time, a r can absorb moisture and show a decrease in IR. In many , depending on the supply voltage and the application, the r can be safely energized and will dry itself out.

If a heater has absorbed moisture, a safe and effective method of drying it out prior to installation is to bake it in an oven at 300°F (149°C) until an acceptable IR reading is obtained. When possible, removing the terminal hardware will expedite this process. If this method is not practical consult factory for other recommendations.

For applications where moisture absorption would be unacceptable Tempco has several optional element end seals to retard absorption of moisture in the MgO. If a true hermetic seal is required, ceramic to metal end seals (Type H) are available. With any of these seals, the maximum recommended operating temperature must not be exceeded.

SS—Silicone Resin Seal

shed-on coating that penetrates the MgO, offering econom- oisture protection under humid storage conditions.

mum Usable Termination Temperature: 390°F (200°C)
ated Maximum Termination Temperature: 221°F (105°C)

V2A: conformal coating
V2B: silicone oil

SER—RTV Seal

room temperature vulcanizing) silicone rubber adhesive t provides a good moisture seal.

ated – Maximum Termination Temperature:

R: 302°F (150°C)
R1: 392°F (200°C)

Style SEH—Epoxy Resin Seal

Epoxy resin provides a moisture resisting barrier.

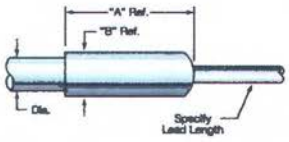
UL Rated – Maximum Termination Temperature:

Type V: 194°F (90°C)
Type V1: 266°F (130°C)
Type V3: 356°F (180°C)
Type V4: 392°F (200°C)

TYPE M—Self Sealing Heat Shrinkable Boot with Lead Wire

This type seal is used primarily for defrost heaters. Temperature range -67 to 300°F (-55 to 149°C). Standard 10" (254 mm) leads; specify longer leads if required.

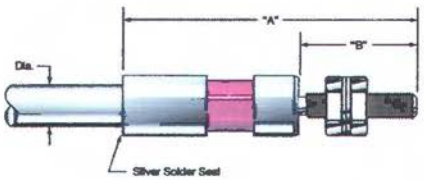
Heater Diameter in	Heater Diameter mm	"A" in	"A" mm	"B" in	"B" mm
.260	6.6	2-1/8	54	7/16	11
.315	8.0	2-1/8	54	7/16	11
.430	10.9	2-1/8	54	9/16	14



TYPE H—Hermetic Seal

Ceramic to metal seals provide an airtight seal for temperatures to 500°F (260°C) in the seal area.

Heater Diameter in	Heater Diameter mm	"A" in	"A" mm	"B" in	"B" mm	Thread Size
.260	6.6	1-11/16	43	13/32	10	8-32
.315	8.0	1-11/16	43	13/32	10	10-32
.430	10.9	2-1/8	54	21/32	17	1/4-28
.475	12.1	2-1/8	54	21/32	17	1/4-28



Tubular Heater Standard Bend Formations

Forming Tubular Elements

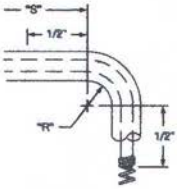
ulation used in tubular heating elements is compacted by element diameter in a roll reducing mill. The elements ealed in a controlled atmosphere furnace to relieve the ng (work hardening) that takes place during the rolling to n of the sheath. Annealing brings the metal back to a soft ig the element to be bent into virtually any configuration. ice forming also work hardens the metal, some precau- e observed in order to prevent the sheath from breaking ng or developing stress cracking marks.

Elements with tight bends and some applications require the s to be recompacted in special dies to restore the integrity of the ation density and maintain dielectric strength. Large bends do eed to be recompacted.

Tubular Element Minimum Bending Radius

Element Diameter		Factory Bend Minimum R		Field Bend Minimum R		Minimum S	
in	mm	in	mm	in	mm	in	mm
.260	6.6	3/8	9.5	3/4	19.1	1/2	12.7
.315	8.0	1/2	12.7	1	25.4	1/2	12.7
.375	9.5	9/16	14.3	2	50.8	5/8	15.9
.430	10.9	3/4	19.1	2-1/2	63.5	3/4	19.1
.475	12.0	7/8	22.2	2-1/2	63.5	1	25.4

Note: Smaller inside bending radius than listed in the table can be factory accomplished. It requires special forming techniques to prevent damage to the tubular heater. Consult Tempco with your requirements.

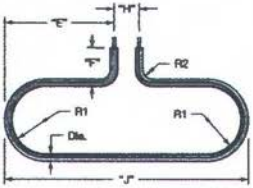


Avoid bends within a minimum of 1/2" of the terminal pin and resistance wire junctions unless the bending radius is a minimum 3"(75 mm).


Elements are being fed into a roll reducing mill to compact the MgO insulating powder. After rolling, the elements are annealed in the conveyor belt furnace seen in the background.

PICAL Bend Formations

FT1



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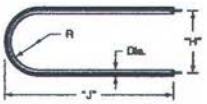
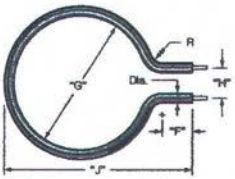


FT3

FT4



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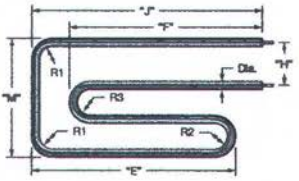
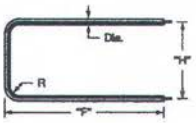


FT6

Tubular Heater Standard Bend Formations



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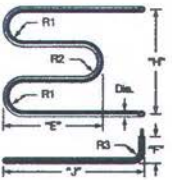

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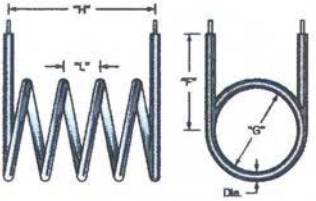

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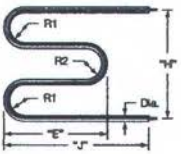

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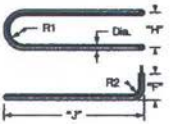

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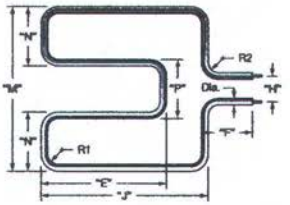

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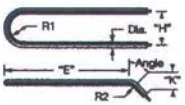

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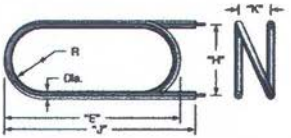

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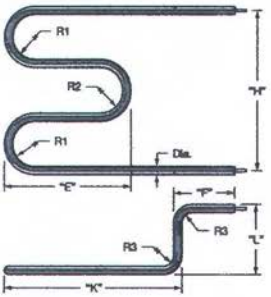

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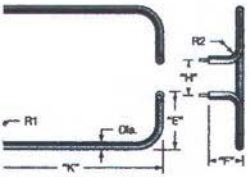

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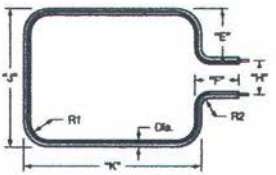

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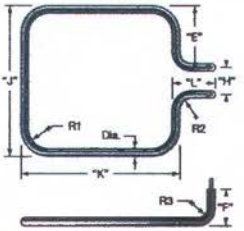
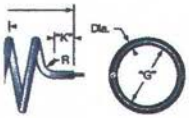


FT18

Tubular Heater Standard Bend Formations



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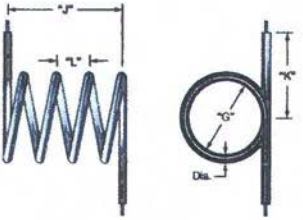

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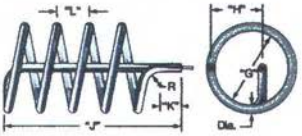
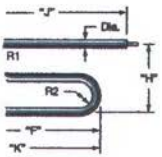


FT21

TYPICAL Bend Formations



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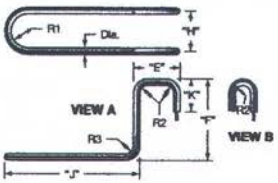

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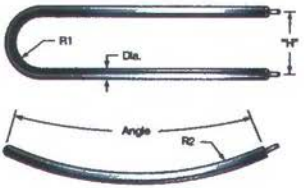

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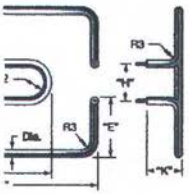

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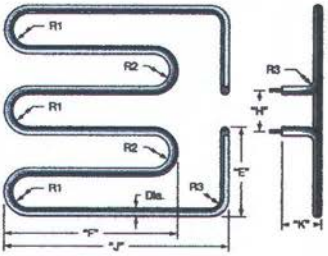

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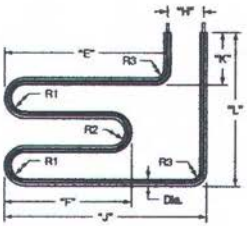
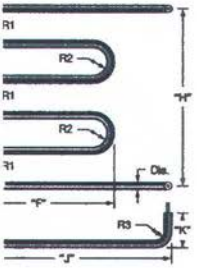


FT27

Tubular Heater Standard Bend Formations



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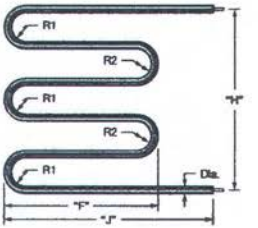

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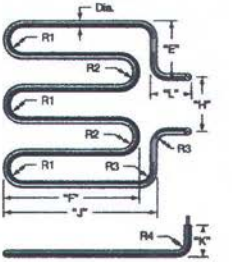

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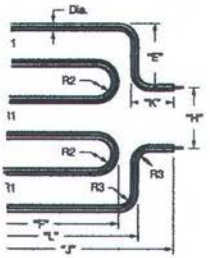
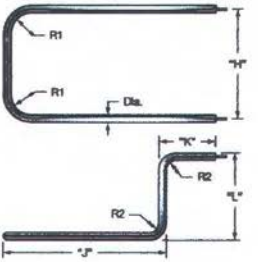


FT31



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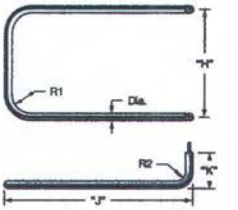

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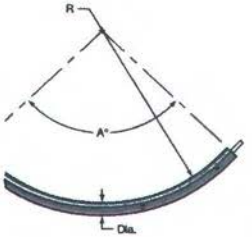

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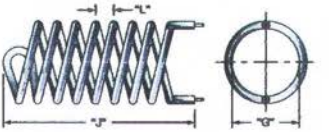
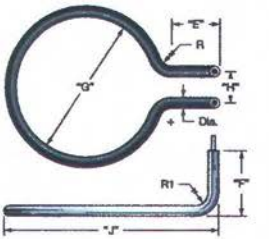
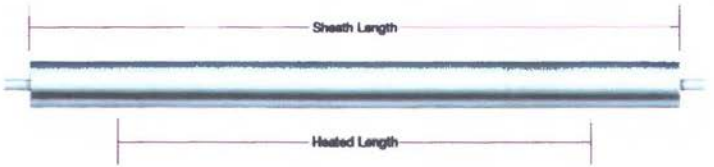


FT35



FT36

Tubular Heater Standard (Non-Stock) and Stock Sizes and Ratings



Standard tubular heaters are fully annealed for field or factory bending. They are inventoried with plain pin extensions that allow quick installation of Termination Types T, TM, F1, A, E, SF, SF9, L and L9.

Part Numbers listed are for heaters with Type "T" termination. For other terminations a Part Number will be issued at time of order.

Standard (Non-Stock) and Stock Sizes and Ratings with Type T Termination

Element Description	Sheath Length in	Sheath Length mm	Heated Length in	Heated Length mm	Watts	Part Number 240V	Approximate Net Weight lbs	Approximate Net Weight kgs
23 W/in² .475 Dia. Incoloy® 840 12 mm (3.6 W/cm²)	39	991	27	686	1000	*THE04000	1.0	.5
	54	1372	42	1067	1500	*THE04001	1.1	.5
	69	1753	57	1448	2000	*THE04002	1.3	.6
	84	2134	72	1829	2500	*THE04003	1.4	.6
	99	2515	87	2210	3000	*THE04004	1.6	.7
	132	3353	120	3048	4175	THE04005	1.7	.8
	157	3988	145	3683	5000	THE04006	1.8	.8
30 W/in² .260 Dia. Incoloy® 840 6.6 mm (4.7 W/cm²)	20	508	15	381	400	THE04007	.2	.1
	25	635	20	508	500	THE04008	.2	.1
	30	762	25	635	600	*THE04009	.2	.1
	35	889	30	762	800	*THE03384	.3	.1
	40	1016	35	889	900	*THE04010	.3	.1
	45	1143	40	1016	1000	*THE04011	.4	.2
	50	1270	45	1143	1200	*THE04012	.4	.2
	55	1397	50	1270	1200	*THE03383	.4	.2
	60	1524	55	1397	1400	*THE03373	.5	.2
	65	1651	60	1524	1600	*THE02648	.5	.2
	70	1778	65	1651	1800	THE04013	.6	.3
	75	1905	70	1778	1800	THE04014	.6	.3
	80	2032	75	1905	2000	THE04015	.6	.3
30 W/in² .315 Dia. Incoloy® 840 8.0 mm (4.7 W/cm²)	15	381	10	254	300	THE04016	.2	.1
	20	508	15	381	400	THE04017	.3	.1
	25	635	20	508	600	THE04018	.3	.1
	30	762	25	635	800	*THE04019	.4	.2
	35	889	30	762	900	*THE03328	.5	.2
	40	1016	35	889	1000	*THE04020	.5	.2
	45	1143	40	1016	1200	*THE04021	.6	.3
	50	1270	45	1143	1400	*THE04022	.7	.3
	55	1397	50	1270	1600	*THE04023	.7	.3
	60	1524	55	1397	1800	*THE03134	.8	.4
	65	1651	60	1524	1800	*THE04024	.9	.4
	70	1778	65	1651	2000	*THE03380	1.0	.5
	75	1905	70	1778	2200	THE04025	1.0	.5
	80	2032	75	1905	2400	THE04026	1.1	.5
	90	2286	85	2159	2600	THE04027	1.2	.5
	100	2504	95	2413	3000	THE04028	1.3	.6

An asterisk (*) next to the Part Number guarantees IN-STOCK availability for same-day shipping when ORDERED BY 2 PM CST

CONTINUED

Tubular Heater Standard (Non-Stock) and Stock Sizes and Ratings

Standard (Non-Stock) and Stock Sizes and Ratings with Type T Termination

Element Description	Sheath Length in	Sheath Length mm	Heated Length in	Heated Length mm	Watts	Part Number 240V	Approximate Net Weight lbs	Approximate Net Weight kgs
30 W/in² .430 Dia. Incoloy® 840 10.9 mm (4.7 W/cm²)	15	381	10	254	400	THE04029	.3	.1
	20	508	15	381	600	THE04030	.5	.2
	25	635	20	508	800	THE04031	.6	.3
	30	762	25	635	1000	THE04032	.7	.3
	35	889	30	762	1200	THE04033	.8	.4
	40	1016	35	889	1400	THE04034	.9	.4
	45	1143	40	1016	1600	THE04035	1.0	.5
	50	1270	45	1143	1800	THE04036	1.1	.5
	55	1397	50	1270	2000	*THE03415	1.3	.6
	60	1524	55	1397	2200	*THE03376	1.4	.6
	65	1651	60	1524	2400	*THE04037	1.5	.7
	70	1778	65	1651	2600	*THE04038	1.6	.7
	75	1905	70	1778	2800	*THE04039	1.7	.8
	80	2032	75	1905	3000	*THE04040	1.8	.8
	90	2286	85	2159	3500	*THE04041	2.0	.9
	100	2540	95	2413	4000	*THE03593	2.3	1.0
	110	2794	105	2667	4500	*THE03067	2.5	1.1
	120	3048	115	2921	5000	*THE04042	2.7	1.2
40 W/in² .375 Dia. Incoloy® 840 9.5 mm (6.2 W/cm²)	21 1/16	535	16 1/16	427	800	THE04043	.4	.2
	27 1/16	689	22 1/16	581	1100	*THE04044	.5	.2
	32 1/16	816	27 1/16	708	1300	*THE04045	.6	.3
	42 1/16	1089	38 1/16	981	1800	*THE04046	.8	.4
	57 1/16	1461	53 1/16	1353	2500	*THE04047	1.1	.5
	69 1/16	1759	65	1651	3000	*THE04048	1.3	.6
	81 1/16	2064	77	1956	3600	THE04049	1.5	.7
	109 1/16	2775	105	2667	4000	THE04050	2.1	1.0
	134 1/16	3416	127 1/16	3245	5000	THE04051	2.5	1.1
	153 1/16	3896	145 1/16	3705	5500	THE04052	2.9	1.3
	179 1/16	4553	171 1/16	4350	6500	THE04053	3.4	1.5
48 W/in² .475 Dia. Incoloy® 840 12 mm (7.4 W/cm²)	23	584	14	356	1000	THE04054	.6	.3
	30	762	21	533	1500	THE04055	.9	.4
	39	991	27	686	2000	THE04056	1.1	.5
	44	1118	35	889	2500	THE04057	1.3	.6
	54	1372	42	1067	3000	THE04058	1.6	.7
	69	1753	57	1448	4000	THE04059	2.0	.9
	84	2134	72	1829	5000	THE04060	2.2	1.0
	99	2515	87	2210	6000	THE04061	2.8	1.3
	149	3785	133	3378	9720	THE04062	4.0	1.8

Ordering Information

Catalog Heaters

Part Numbers preceded by an asterisk (*) are in stock for immediate delivery with Type T termination.

Termination Types TM, F1, A, E, SF, SF9, L, and L9 can be applied to stock heaters. For these terminations the Heater Part Number will be issued at time of order.

Part Numbers with no asterisk are standard designs that are available straight in 2 weeks and formed in 4 weeks.

Custom Engineered/Manufactured Heaters

Understanding that an electric heater can be very application specific, for sizes and ratings not listed, **TEMPCO** will design and manufacture a tubular heater to meet your requirements. ***Standard lead time is 4 weeks.***

Please Specify the following:

- ❑ Type of Application
- ❑ Wattage and Voltage
- ❑ Diameter
- ❑ Heated Length
- ❑ Unheated Length at Each End
- ❑ Sheath Material
- ❑ Termination Type
- ❑ Type of Mounting, if Required
- ❑ Type of Moisture Seal, if Required
- ❑ Bending Configuration (supply Drawing and/or Sample)

Tubular Heaters for Hot Runner Manifolds

Construction

Hot Runner Manifold Heaters are made to order using .260", .315" or .375" diameter Incoloy® tubular heating elements. Commonly specified terminations include threaded stud or wire leads.

Important Information on Forming

Precise forming of the tubular heater is required for it to seat properly into the milled slot in the manifold. To ensure this fit, we use a physical template as an inspection tool in the forming process to verify bending accuracy.

The template is a reproduction of the milled slot in the form of a plastic or aluminum plate. It can be customer supplied or manufactured by Tempco. Only through the use of a forming template is bending accuracy guaranteed.

When ordering for new applications:

Supply a drawing or forming template if available.

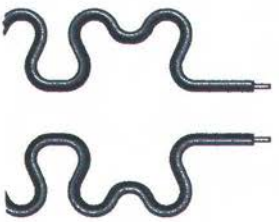
When ordering for replacement:

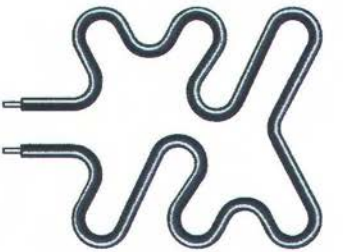
Supply a sample heater and/or a drawing of the manifold indicating the milled heater slot.

Note: For heaters originally manufactured by Tempco only the Tempco Part Number is required.

s of Mold Heater Formations

t Tempco With Your Requirements. We Welcome Your Inquiries.





Heat Transfer Cement

ar heating elements are used in a milled gaps between the element and the plate ıot spots on the element. Heat transfer sed to fill these air gaps, permitting the run cooler, thus maximizing its life . Cement is water soluble and can be ı a putty knife or trowel and can be used ures up to 1250°F (675°C).

ɔer **SEA-108-101 (1 Gallon)**
SEA-108-102 (1 Quart)

Ordering Information

TEMPCO will design and manufacture a Tubular Hot Runner Manifold Heater to meet your requirements.

Please Specify the following:

- ❑ Wattage and Voltage
- ❑ Diameter
- ❑ Heated Length
- ❑ Unheated Length at each end
- ❑ Termination Type (see pages 10-4 and 10-5)

Product Inventory Available for Viewing and Selection @ www.tempco.com

Finned Tubular Heaters

ıco finned tubular heaters provide rapid heat transfer for natural convec-
ır forced air space heating in industrial process air heating systems.

ɔd tubular heaters start out as a standard tubular heater with the fins being
ıed on a custom built finning machine.

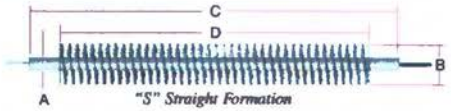
ılard Sizes and Materials

ɔtainless Steel .475" diameter tubular element with 1.12" diameter fin.
er Clad Steel .430" diameter tubular element with 1.31" diameter fin.

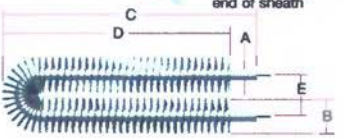
: materials available for the element sheath and fins include Monel, 316
less Steel and Steel with high temperature aluminum paint.

:ifications

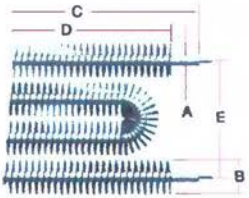
eter: .315", .430", .475"
rial: 304SS, 316SS, Steel Copper Clad, Monel, Steel
Sheath Length: 11"
Sheath Length: 256"
Fin Diameter: 1.31", 1.14", 1.12", 0.84"
Terminations: All Tubular Heater
Max. Volts: 480 Vac
Max. Amperage: 40 Amp



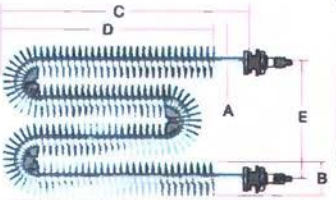
"S" Straight Formation



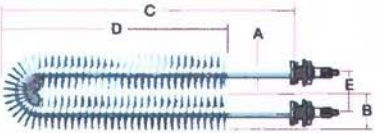
"U1" Bend Formation



"M1" Bend Formation



"M2" Bend Formation with Bulkhead Fittings



"U2" Bend Formation with Bulkhead Fittings

Ordering Information, Finned Tubular Heaters

Please Specify the following:

- ❑ Sheath/Fin Material
- ❑ Bulkhead Fittings
- ❑ Terminations and Seals
- ❑ Bend Formations and Dimensions
- ❑ Mounting Flange
- ❑ Sheath Diameter
- ❑ Wattage and Voltage

Single-Ended Tubular Heaters

Single-Ended Tubular Heater manufacturing and design
ss is similar to that of the double ended tubular heater. Single
tubular heaters are made strictly per customer request, pro-
ɜ an economical alternative to cartridge heater applications,
ifying wiring and installation for applications requiring
zed heat. Flanges, bulkhead and NPT fittings can be attached
sheath for mounting or immersion heating applications.

Specifications

Diameters: .315" .430" .475".490", .625"
Material: 304SS, 316SS, Steel Copper Clad, Monel, Steel
Min. Sheath Length: 11"
Max. Sheath Length: 96"
Termination: Lead Wires
Max. Volts: 277 Vac
Max. Amperage: 30 Amp

Ordering Information Single-Ended Tubular Heaters

Please Specify the following:

- ❑ Sheath Material and Diameter
- ❑ Heater Length and Cold Ends
- ❑ Bulkhead Fittings
- ❑ Wattage and Voltage
- ❑ Terminations and Seals
- ❑ Mounting Flange

lar Heaters

Request

Tubular Heater, Finned Tubular Heater and Single Ended Tubular Heater Quote Request

Made-To-Order Quote Request Form — Copy and Fax us your requirements.

Customer Drawing

_____

_____

_____

_____

_____

_____ Fax _____

_____

Application Information

in Detail _____

_____

_____

mersion _____

Load Temperature _____

_____

Specifications

ıdard _____ Finned _____ Single Ended _____

aterial _____

_____ **Fin Dia.** *if applies* _____

eath Length _____

ion: 1st end _____ 2nd end _____

_____ **Volts** _____

___ **cUL** _____ **CSA** _____ **CE** _____

on Type _____ *(Type T – standard screw)*

tandard Options _____

_____

: MC ___ LR ___ Location: _____ MF ___

ulkhead Fittings ___ **Material** ___ **Flange Type** ___

f Custom _____

_____

_____

Moisture Seals

Moisture Seals: None ____

Optional: Style SS: Type V2A____ Type V2B____

Style SER: Type R ____ Type R1 ____

Style SEH: Type V ____ Type V1 ____

Type M ____ Type H ____

Describe if Custom _____

_____

_____

Optional Sheath Surface Treatments

(For Incoloy® and Stainless Steel Sheath Elements only)

Passivation _____ **Bright Annealing** _____

Electro-Polishing _____

Other _____

_____

_____

Bends and Shapes

Standard Formation Code _____

Specify Letters and Corresponding Dimensions Below:

__ ____ __ ____ __ ____ __ ____ __ ____ __ ____

__ ____ __ ____ __ ____ __ ____ __ ____ __ ____

__ ____ __ ____ __ ____ __ ____ __ ____ __ ____

Number of Bends *if known*

Single/Multiple _____ Plane _____

Coils/Turns _____ Dia. _____

Circle: Full ___ Dia. ___ Partial ___ Degree ___

Describe if Custom: _____

_____

_____

_____

Product Inventory Available for Viewing and Selection @ www.tempco.com

LAMPIRAN E
UCAPAN TERIMA KASIH

Pada pengerjaan Tugas Akhir ini, penulis telah dibantu oleh beberapa pihak yang telah membantu terlaksananya pengerjaan Tugas Akhir ini. Adapun beberapa pihak tersebut adalah :

- **ALLAH SWT. dan Nabi MUHAMMAD SAW.**

Terima kasih yang utama dipanjatkan kepada Allah SWT atas petunjuk, karunia, bimbingan, dan ridlo-Nya serta Nabi Muhammad SAW sebagai panutan penulis dalam kehidupan sehingga penulis mampu untuk melaksanakan dan menyelesaikan Tugas Akhir ini.

- **Keluarga Besar Penulis**

Keluarga Besar dari sang penulis ini yang telah memberikan dukungan terbesar baik secara spiritual maupun material. Dukungan yang diberikan selama ini telah membuat sang penulis mampu mengerjakan Tugas Akhir ini dengan lancar serta menjadikan sang penulis menjadi manusia yang paling berarti dalam hidup baik untuk diri sendiri maupun orang lain. Suasana hangat dalam kehidupan berkeluarga merupakan dukungan moral bagi sang penulis dalam pengerjaan Tugas Akhir ini, Terima kasih terutama buat Ayah, Ibu dan AdekQ Tercinta...

- **Orang Tua Penulis di Kampus**

Para dosen yang telah membuat sang penulis menjadi orang yang berilmu dan bermanfaat bagi lingkungan. Dosen – dosen yang membantu dan melancarkan pengerjaan Tugas Akhir ini merupakan bantuan yang sangat utama dalam kelancaran pengerjaan Tugas Akhir ini. Terima kasih...