Technical Information

Enclosure Paint Finishes

Other considerations in selecting a paint type include:

- Lighter colors will dissipate heat and lower the temperature of internal equipment; darker colors will retain heat and increase the temperature of the cabinet interior. In outdoor applications lighter colors reflect sunlight and operate at lower temperatures.
- For severely corrosive applications, an inhibiting primer with an overcoat of epoxy or urethane is recommended.
- Textured finishes are generally less expensive, easier to touch-up, do not show fingerprints as readily and provide an attractive appearance; a textured paint finish is more difficult to clean.
- Some epoxy paints chalk and lose gloss.
- Safety concerns or corporate specifications may be considered in selecting a color; however, some special colors may add cost and increase lead times.

Topcoating Powdercoated Enclosures

Rittal uses the latest electrostatic powder coating technology to deposit a premium powder paint on enclosures; however, some applications may require a topcoating to meet unique specifications such as a color change or material requirement.

A topcoat can be applied to the existing powdercoat using the instructions below:

Topcoat Material	Application Instructions
Air Dry Acrylic Lacquer Hi-Solid Catalyzed Acrylic Hi-Solid Two Part Urethane Automotive Air Dry Acrylic Vinyl Air Dry Hi-Solid Polyester Bake Enamel	Wipe the enclosure surfaces to be topcoated with a clean solvent cloth. Allow the solvent to flash dry for approximately 5 minutes and apply the finish as directed by the paint supplier.
Air Dry Alkyd Hi-Solid Polyamide Epoxy	Lightly sand all surfaces to be topcoated with 320 grit or finer sandpaper. Wipe all surfaces with a clean isopropyl alcohol impregnated cloth. Allow the solvent to flash dry for 5 minutes and apply the finish as directed by the paint supplier.

If the topcoat material does not appear in the table, consult Rittal.

Surface preparation for painting galvanized surfaces
Solvent or detergent wiping

Cleaning galvanized surfaces with solvents or alkaline detergents is an accepted surface preparation procedure for galvanized coating applications. Oil and grease can be removed with rags or brushes saturated in solvents, such as high-flash naphtha. Trisodium phosphate or similar alkaline detergents also work well.

For surfaces with heavier oil or dirt buildups, stronger solvents, such as acetone or methyl ethyl ketone, may be necessary. Along with these products, there are a number of chemical cleaners on the market that are specifically formulated for preparing galvanized substrates. These products provide good alternatives to dangerous, explosive solvents and are effective at removing surface contaminants and portions of the oxide and hydroxide films.

To achieve good results with solvents and detergents, special cleaning procedures must be followed. Wiping rags and solvent and detergent cleaning pails should be changed frequently to ensure that all residual oil is removed. Thorough rinsing is also important. The use of high pressure water is necessary for removing detergent residue that can interfere with paint adhesion.

Wash priming

Wash or etch primers have been successfully used to passivate zinc surfaces for painting. The primers create a finish that is conducive to a range of coatings through the conversion of resin into a relatively insoluble film. Wash primers are applied through spray application in one coat of usually 0.5 mil or less. They dry in 15-30 min and can be recoated in under 1 hr. To maximize the neutralizing effect of these primers, topcoating must be performed as soon as possible, usually within 4 hr.

Selecting the right coating

Equally important as surface preparation is proper coating selection. Typically, a galvanized coating system involves a primer and topcoat. However, some coatings now on the market are self-priming and may be applied directly to properly prepared galvanized surfaces.

Just as with any coating application, the type of system employed is dependent on specific performance requirements and environmental factors. Selection of the right system is as much a matter of knowing what doesn't work well as what does.

For mild to moderately corrosive environments, direct-to-metal acrylics are a good choice. These coatings provide superior adhesion, are corrosion resistant, and exhibit superior gloss, color retention, and flexibility. They can be used as an intermediate/finish coat over a wash primer or applied directly to the galvanized substrate as a topcoat.

In aggressive environments where enhanced chemical resistance and durability are needed, certain types of epoxies are most appropriate. Polyamide epoxies are commonly used as primers with amine epoxy topcoats. This type of system offers superior adhesion and water and chemical resistance for the highest level of protection.

Traditional alkyds and oil-based coatings should never be considered as primers or topcoats on galvanized steel. The alkaline surface generated by zinc causes these types of coatings to saponify or turn to soap. As a result, peeling and flaking occur quite early, despite initial satisfactory adhesion.

Reprinted with permission from PLANT ENGINEERING magazine, April 1998, "Painting Galvanized Surfaces Successfully."

Technical Information

Non-Metallic Properties

Physical Properties Of Non-Metallic Materials

Table 7 provides technical data for assistance in evaluating non-metallic enclosures and selecting the materials used with Legacy fiberglass enclosure accessories. Additional considerations for inclusion in the fiberglass enclosure specification are:

- The resin system shall be pigmented grey unless otherwise specified.
- The resin system shall include a flame retardant to obtain a flammability rating which meets UL 94-5V.
- The heat distortion temperature shall be at least 350°F.
- Standard cover screws shall be stainless steel or stainless steel with fiberglass encapsulated heads. Other hardware items such as hinges and latches shall be stainless steel or fiberglass construction.
- External mounting feet shall be molded or securely attached to the enclosures to provide a corrosion resistant surface mounting system.

Table 7. Physical Properties Of Non-Metallic Materials

Materials Typical Properties	Test Method ASTM	Polyester Fiberglass (SMC)	Polyester Fiberglass Hand Lay-up	Polyester Fiberglass Pultrusion	Acrylic Sheet for Windows	Dispensed Silicone Gaskets	Foamed Urethane Gaskets	Extruded Silicone Gaskets	Neoprene Gaskets
Flexural Strength (psi)	D 790	18K	30K	45K	16K	N/A	N/A	N/A	N/A
Notched Izod (ft - lb/in @ 1/8")	D 256	7-22	5-30	25	0.3-0.4	N/A	N/A	N/A	N/A
Impact Resistance (lb-in)	UL 746C	≥216	—	—	—	N/A	N/A	N/A	N/A
Compressive Strength (psi)	D 695	20K	35K	26K	18K	N/A	N/A	N/A	N/A
Tensile Strength (psi)	D 638	8K	17.5K	40K	10.5K	200	60	100	500
Specific Gravity	D 792	1.77	1.5-2.1	1.7	1.17-1.20	1.32	0.3	0.55	1.24
Flammability	UL 94	V-0 & V-5	—	V-0	—	—	—	—	—
Heat Deflection (°F at 264 psi)	D 648	375-500	>400	<400	205	N/A	N/A	N/A	N/A
Service Temperature Range (°F)		-40°F to 250°F	-40°F to 250°F	-40°F to 250°F	-31°F 180°F	-40°F to 350°F	-40°F to 200°F	-100°F to 500°F	-40°F to 225°F
K Factor, Thermal Conductivity (BTU/hr/ft²/°F/in)		1.68	1.68	1.68	1.3	1.3	1.0	1.3	1.45
Dielectric Strength (VPM)	D 149	380	380	200	500	400	330	400	400
Arc Resistance (sec)	D 570	200+	200+	80	No Track	N/A	N/A	N/A	N/A
Water Absorption (% in 24 hr)	D 570	0.10-0.25	0.05-0.5	0.05-0.5	<0.4	0.12-0.15	<2	5	—
Hardness (Barcol-Rockwell M-Shore A)		50-70 Barcol	60-80 Barcol	50 Barcol	105 Rockwell	18 Shore	8 Shore	—	15-95 Shore
Shrinkage in/in Minimum		.005	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Elongation (%)		N/A	N/A	N/A	N/A	850	100	400	100-800
Compression Set 24 hr @ 50%, 72°F		N/A	N/A	N/A	N/A	<5%	<2%	<5%	15-60

– no test data available
K = 1000
N/A not applicable
all materials are UL listed

Technical Information

Non-Metallic Properties

Enclosure Load Capacity

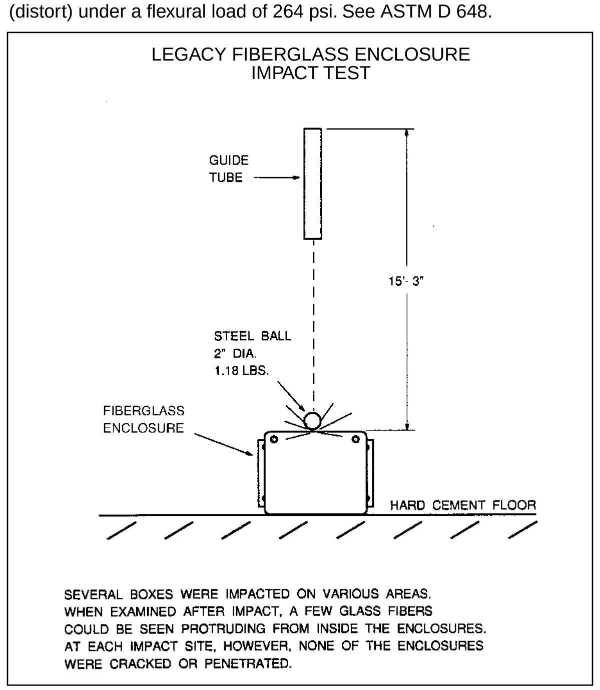
Large control enclosures can support 200 lbs of equipment on the back panel. Smaller junction and instrumentation enclosures should be limited to 75 lbs Listed values assume the enclosure is vertically mounted against a reasonably flat surface and are based on a minimum safety factor of two.

Maximum Temperature Rating

The deflection temperature* of polyester fiberglass ranges from 375-500°F. Rittal has conducted tests on enclosures at sustained temperatures of 350°F. Polyester fiberglass is a high temperature material compared to other polymers such as PVC, polycarbonate or engineered thermoplastics.

In elevated temperature applications, the highest temperature an enclosure can withstand depends on other components used in the finished product. Such items as PVC air vents, and special gaskets must be considered when establishing a temperature limit for both fiberglass and metal enclosures. Many times this issue is neglected or minimized when rating the product.

*Deflection temperature: The temperature when a material will deflect (distort) under a flexural load of 264 psi. See ASTM D 648.



Integrity of the enclosure was not compromised

Sunlight (UV) Resistance

In time, sunlight may roughen the fiberglass enclosure surface, but its electrical and mechanical properties remain unaffected. Surface roughening caused by UV exposure is a common phenomenon encountered with virtually all fiberglass products, but it only affects surface appearance. Tests have confirmed the effect on polyester fiberglass is only 40 to 80 microns (0.0015"-.003") in depth. If appearance is a concern, an outdoor acrylic paint (clear or pigmented) will provide protection for many years. Most acrylic paints in ordinary spray cans work well.

Drilling, Sawing, Cutting and Punching

Installers find fiberglass easy to cut or drill. Ordinary drills, hacksaws, hole saws and punches cut through fiberglass with little effort. In large installations requiring many holes, glass abrasion may cause tools to become dull over time. Carbide tip tools work best for such applications. For maximum accuracy, routing of openings is recommended.

Impact Resistance

Rittal's Legacy fiberglass enclosures are quite resistant to damage caused by falling tools or flying debris. When tested in accordance with UL Standard 746C, Section 24, these fiberglass enclosures withstood an impact in excess of 216 lbs/inches. The test was performed by dropping a 2" diameter solid steel ball on various areas of the enclosure from a height of 15 ft. The impact force from such a test is comparable to dropping a large wrench from 3 or 4 ft. The durability results from randomly oriented glass reinforcing fibers incorporated in all designs.

Technical Information

National Electrical Code Allowable Conductor Ampacity

Table 310-16

Allowable ampacities of insulated conductors rated 0-2000 Volts, 60° to 90°C (140° to 194°F) NOT MORE THAN THREE CONDUCTORS in raceway or cable or earth (directly buried), based on air ambient temperature of 30°C (86°F).

Size	Temperature Rating of Conductor		
	60°C (140°F)	75°C (167°F)	90°C (194°F)
AWG kcmil	Type TW†, UF†	Type FEPW†, RH†, RHW†, THHW†, THW†, THWN†, XHHW†, USE†, ZW†	Type TA,TBS,SA, SIS, FEP†, FEPB†, MI, RHH†, RHW-2, THHN†, THHW†, THW-2, THWN-2, USE-2, XHH, XHHW†, XHHW-2, ZW-2
		Copper	
18	–	–	14
16	–	–	18
14	20 †	20 †	25 †
12	25 †	25 †	30 †
10	30	35 †	40 †
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430
600	355	420	475
700	385	460	520
750	400	475	535
800	410	490	555
900	435	520	585
1000	455	545	615
1250	495	590	665
1500	520	625	705
1750	545	650	735
2000	560	665	750

Table 310-17

Allowable ampacities of single insulated conductors, rated 0-2000 Volts, in free air, based on ambient air temperature of 30°C (86°F).

Size	Temperature Rating of Conductor		
	60°C (140°F)	75°C (167°F)	90°C (194°F)
AWG kcmil	Type TW†, UF†	Type FEPW†, RH†, RHW†, THHW†, THW†, THWN†, XHHW†, ZW†	Type TA,TBS,SA, SIS, FEP†, FEPB†, MI, RHH†, RHW-2, THHN†, THHW†, THW-2, THWN-2, USE-2, XHH, XHHW†, XHHW-2, ZW-2
		Copper	
18	–	–	18
16	–	–	24
14	25 †	30 †	35 †
12	30 †	35 †	40 †
10	40 †	50 †	55 †
8	60	70	80
6	80	95	105
4	105	125	140
3	120	145	165
2	140	170	190
1	165	195	220
1/0	195	230	260
2/0	225	265	300
3/0	260	310	350
4/0	300	360	405
250	340	405	455
300	375	445	505
350	420	505	570
400	455	545	615
500	515	620	700
600	575	690	780
700	630	755	855
750	655	785	885
800	680	815	920
900	730	870	985
1000	780	935	1055
1250	890	1065	1200
1500	980	1175	1325
1750	1070	1280	1445
2000	1155	1375	1560

† Unless otherwise specifically permitted elsewhere in this Code, the overcurrent protection for conductor types marked with an obelisk (†) shall not exceed 15 amperes for No. 14, 20 amperes for No. 12, and 30 amperes for No. 10 copper, after any correction factors for ambient temperature and number of conductors have been applied.

Temperature Correction Factors

For ambient temperatures other than 30°C (86°F), multiply the allowable ampacities shown above by theappropriate factor shown below.

Ambient Temp. °C	60°C	75°C	90°C
30	1.00	1.00	1.00
40	.82	.88	.91
50	.58	.75	.82
60	–	.58	.71
70	–	.33	.58
80	–	–	.41

Adjustment Factors For More Than Three Current-Carrying Conductors In A Raceway Or Cable.

Where the number of current-carrying conductors in a raceway or cable exceeds three, the allowable ampacities shall be reduced as shown in the following table.

Number of current-carrying conductors	Percent of values in tables as adjusted for ambient temperature if necessary
4 through 6	80
7 through 9	70
10 through 20	50
21 through 30	45
31 through 40	40
41 and above	35

Technical Information

Conversions and Formulas

British And U.S. Dimensions For Cables And Lines

AWG No.	Diameter mm	Cross-section mm^2	Consuctor resistance Ω/km
500	17.96	253	0.07
350	15.03	177	0.1
250	12.7	127	0.14
4/0	11.68	107.2	0.18
3/0	10.4	85	0.23
2/0	9.27	67.5	0.29
1/0	8.25	53.5	0.37
1	7.35	42.4	0.47
2	6.54	33.6	0.57
4	5.19	21.2	0.91
6	4.12	13.3	1.44
8	3.26	8.37	2.36
10	2.59	5.26	3.64
12	2.05	3.31	5.41
14	1.63	2.08	8.79
16	1.29	1.31	14.7
18	1.024	0.823	23

Formulas For Electrical Motors

To find	Direct current	Single phase	Three phase
Horse Power	$\frac{E \times I \times EFF}{746}$	$\frac{E \times I \times EFF \times PF}{746}$	$\frac{1.732 \times E \times I \times EFF \times PF}{746}$
Current	$\frac{746 \times HP}{E \times EFF}$	$\frac{76 \times HP}{E \times EFF \times PF}$	$\frac{746 \times HP}{1.732 \times E \times EFF \times PF}$
Efficiency	$\frac{746 \times HP}{E \times I}$	$\frac{746 \times HP}{E \times I \times PF}$	$\frac{746 \times HP}{1.732 \times E \times I \times PF}$
Power Factor	—	$\frac{\text{Input Watts}}{E \times I}$	$\frac{\text{Input Watts}}{1.732 \times E \times I}$

E = Volts EFF = Efficiency (decimal) HP = Horsepower I = Amperes PF = Power factor (decimal)

Formulas For Electrical Circuits

To find	Direct current	Single phase	Three phase
Amperes	$\frac{\text{Watts}}{\text{Volts}}$	$\frac{\text{Watts}}{\text{Volts x Power Factor}}$	$\frac{\text{Watts}}{\text{1.732 x Volts x Power Factor}}$
Volt-Amperes	—	Volts x Amperes	1.732 x Volts x Amperes
Watts	Volts x Amperes	Volts x Amperes x Power Factor	1.732 x Volts x Amperes x Power Factor

References Formulas

OHMS Law	Capacitance in microfarads at 60 HZ
Ohms = Volts/Amperes (R = E/I)	Capacitance = $\frac{\text{2650 x Amperes}}{\text{Volts}}$
Amperes = Volts/Ohms (I = E/R)	
Volts = Amperes x Ohms (E = IR)	Capacitance = $\frac{\text{2.65 x kVAR}}{(\text{Volts})^2}$

Length	Multiply By
1 inch = 25.4 mm	? x 25.4 = mm
1 inch = 2.54 cm	? x 2.54 = cm
1 foot = 304.8 mm	? x 304.8 = mm
1 foot = 30.4 cm	? x 30.4 = cm
1 foot = .304 m	? x .304 = m
1mm = .039 inch	? x .039 = inch
1cm = .394 inch	? x .394 = inch
1m = 39.37 inch	? x 39.37 = inch
1m = 3.28 ft.	? x 3.28 = ft.
1m = 1.09 yds.	? x 1.09 = yds.
1 lb = .454 kg	? x .454 = kg
1 kg = 2.2 lbs	? x 2.2 = lbs
1 BTU = .29 watts	? x .29 = watts
1 watt = 3.412 BTU	? x 3.412 = BTU
1cfm = .591 cmh	? x .591 = cmh
1 cmh = 1.692 cfm	? x 1.692 = cfm
1 newton = .225 lb	? x .225 = lb
1 lbf = 4.45 newton	? x 4.45 = newton
1 Kilopaseal = 0.14504 lbf/in²	? x .14504 = lbf/in²

Metal Gauge Thickness		
Gauge	Inches	Metric
7 gauge	.179	4
8 gauge	.164	4
9 gauge	.150	4
10 gauge	.134	3.5
11 gauge	.120	3
12 gauge	.105	2.5
13 gauge	.090	2
14 gauge	.075	2
16 gauge	.060	1.8
18 gauge	.048	1.5
20 gauge	.036	1.2

Climate Control

Heat Removal From Enclosures

Introduction

Electronics, and especially micro-electronics, have made modern production technology more efficient. But ever smaller electronic components and increasingly dense packaging in enclosures have also made these complex systems more sensitive to external influences such as temperature, dust, oil, and humidity.

This can cause problems because the failure of just one electronic component may lead to the complete shutdown of an entire assembly line. Resultant costs quickly add up.

Heat especially is the number one enemy of sensitive micro-electronics.

A rule of thumb says that the average life span of semi-conductors is cut in half every time the operating temperature increases 20°F (11°C) over its maximum operating temperature. Yet, high temperatures in enclosures can hardly be avoided because electric equipment such as transformers, power distribution components, programmable controllers, and electronic components all generate heat, also known as power loss.

Power related temperature swings in an enclosure or electronic housing can also be considerable. These swings cause stress and premature aging of electronic components which in turn lead to premature failure.

As mentioned, correct functioning of electronic systems and problem free operation of entire assembly lines depends to a great degree on removing the heat that is generated in enclosures or electronic cabinets. In principle, there are three different ways in which heat can be dissipated: conduction, convection, and radiation.

With **conduction**, matter itself moves heat, without itself moving, energy is passed on from molecule to molecule.

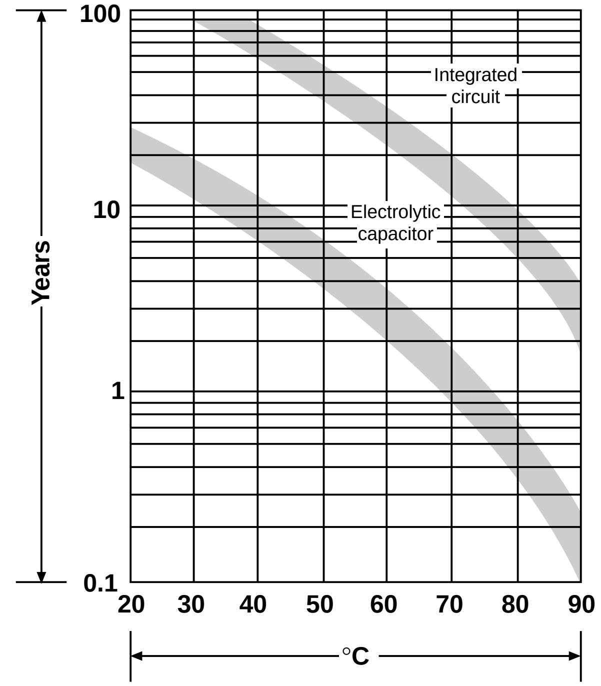
With **convection**, heat is moved through a medium (another material such as a gas or a liquid), the medium absorbs energy in the form of heat and releases energy as heat.

With **radiation**, heat is transferred from one body to another in the form of radiation energy, without any physical matter in between.

Conduction and convection play an important role in enclosures and electronic cabinets; radiation is not a big factor.

An important criterion for heat removal from enclosures is whether the enclosure is an 'open' (air can freely stream through) or 'closed' (air-tight) system. While heat naturally dissipated from the inside of an 'open' enclosure through a flow of air, heat can only be dissipated from a 'closed' system through the walls and roof.

Relationship between electronic component life and temperature



°C = Component temperature
Years = Life span

Climate Control

Heat Removal From Enclosures

Specification Fundamentals

To properly determine the specifications of climate control components, a few simple calculations have to be made. The following terms are used:

- Q_v [Watt]: total power loss (heat loss) of all electric and electronic components that are installed in the enclosure.
- Q_s [Watt]: heat dissipation, or absorption, through the outside surfaces of the enclosure (per VDE 0660, part 500). When the temperature inside the enclosure is higher than the ambient temperature ($T_i > T_u$), heat will be radiated from the enclosure ($Q_s > 0$). When the temperature inside the enclosure is lower than the ambient temperature ($T_i < T_u$), the enclosure will absorb heat from its environment ($Q_s < 0$).
- Q_e [Watt]: required cooling capacity of a climate control component; this is the amount of heat a component must remove from the enclosure.
- Q_H [Watt]: required heating capacity of an enclosure heater.
- T_i [°C]: maximum allowable temperature inside the enclosure per the electronic component manufacturer - usually between +35°C and +45°C.
- T_u [°C]: maximum ambient temperature at which all electronic components inside an enclosure or electronic cabinet should perform faultlessly.
- V [m^3/h]: required air displacement for a filter fan.
- A [m^2]: exposed enclosure surface accordance with DIN 57 600, part 500 or VDE 0600, part 500.
- K [W/m^2K]: heat transfer coefficient of an enclosure:
  sheet steel - 5.5 W/m^2K
  plastic - 3.5 W/m^2K

Table 8

Location of enclosure per VDE 0660, part 500

■ Single enclosure, freestanding
▲ Single enclosure, against a wall
✚ First/last enclosure of a suite, freestanding
◆ First/last enclosure of a suite, against a wall
♠ Enclosure within a suite, freestanding
★ Enclosure within a suite, against a wall
● Enclosure within a suite, against a wall, with covered roof

Location per VDE 0660/500	Formula for calculation of A [m^2]
■	A=1.8 x H x (W+D) + 1.4 x W x D
▲	A=1.4 x W x (H+D) + 1.8 x D x H
✚	A=1.4 x D x (H+W) + 1.8 x W x H
◆	A=1.4 x H x (W+D) + 1.4 x W x D
♠	A=1.8 x W x H + 1.4 x W x D + D x H
★	A=1.4 x W x (H+D) + D x H
●	A=1.4 x W x H + .7 x W x D + D x H
	H = enclosure height [m] W = enclosure width [m] D = enclosure depth [m]

Calculation of exposed enclosure surface

Special attention should be paid to the total exposed enclosure surface because heat loss dissipated from the enclosure depends not only on its actual value, but also on the enclosure's location. An enclosure that stands all by itself in the middle of a room can dissipate more heat than an enclosure that is placed next to a wall or in a corner. For that reason there are special directions on how the total exposed enclosure surface should be calculated depending on its location. These formulas for the calculation of A (see table above) are specified in DIN 57 660, part 500 or VDE 0660, part 500 (see table).

Inherent convection

Inherent convection is the dissipation of heat through the enclosure walls. For this to happen, the ambient temperature must be lower than the temperature in the enclosure. The maximum temperature increase $(\Delta T)_{max}$ that can occur as against the ambient temperature can be calculated with the following formula:

$$(\Delta T)_{max} = \frac{Q_v}{k \cdot A}$$

Note:

When the heat loss within an enclosure is unknown, but the actual ambient temperature T_u and the temperature T_i inside the enclosure can be determined, the actual heat loss can be calculated with the following basic formula:

$$Q_v = A \cdot k \cdot \Delta T \text{ [Watt]}$$

This measurement must be taken with the enclosure sealed and no fans, heat exchangers or air conditioners operating.

Climate Control

General Information

The Need For Climate Control

When the expense of electronic and electrical components and the costly implications of a system's down time are considered, it is important that all reasonable steps are taken to ensure that steady and reliable performance of a system continues. This should, in almost all circumstances, include climate control — cooling and/or heating.

The Purpose Of Cooling

Electronic and electric equipment often generate a great deal of heat during operation. Frequently located in hostile environments, the equipment may also encounter the additional problem of not having safe, clean air available to dissipate unwanted heat. Such adverse conditions affect the performance and the life expectancy of electrical/electronic system components.

Rittal cooling devices are precisely designed to solve the problems of internal heat build-up above component tolerances, excessive ambient temperatures, moisture and contaminant laden atmospheres and corrosive environments, which can affect sensitive electronic equipment. A little time and effort spent early in the design process can save a great deal of trouble and expense later by preventing the need to retrofit with proper cooling devices in the field during a down time situation.

Information Needed For Climate Control Selection

The following information should be on hand to properly size cooling products:

(1) Heat to be dissipated (Watts) by the electrical components inside the enclosure
(2) Maximum temperature expected outside enclosure (°F)
(3) Maximum allowable internal enclosure temperature (°F)
(4) Enclosure dimensions
(5) Mounting portion of enclosure, i.e. against wall, freestanding, in a suite of enclosures, etc.

Request For Climate Control Application Information

To: **Rittal Corporation**
1 Rittal Place
Springfield, Ohio 45504
Climate Control Group
Applications Engineer

Tel. (937) 399-0500
FAX (937) 390-8392
e-mail: Climate-cntl@rittal-corp.com

Date: ____________________

Page 1 of: ____________________

Company: ____________________ Address: ____________________

Contact Name: ____________________ Tel.: ____________________ Project Name/Number: __________

Title: ____________________ Fax: ____________________

Application Questionnaire

1. What is the maximum ambient air temperature? ____________________ °F
2. What is the maximum allowable internal enclosure temperature? __________ °F
3. What is the size and mounting style of the enclosure to be heated or cooled? H _____ W _____ D _____ Mounting: __________ (freestanding,wall, suited)
4. a: What is the measured temperature difference between the outside and inside of the enclosure with the door closed and any vents or openings sealed ____________________ °F

   or

   b: How many Watts or BTUs of heat is given off by the equipment inside the enclosure? ____________________
5. At what voltage and frequency is the climate control device required to operate? Voltage __________ and __________ Hz
6. Is chilled water available for use in conjunction with an air/water heat exchanger? If no, is a chilled water cooling system a viable option? __________
7. Is there a specific NEMA or approval rating that the climate control equipment needs to comply with? NEMA ______ UL ______ CE ______ CSA ______
8. Estimated project commercialization date ____________________
9. Estimated annual climate control product volume ______________ units/year
10. Special requirements or considerations ____________________

Climate Control

General Selection Considerations

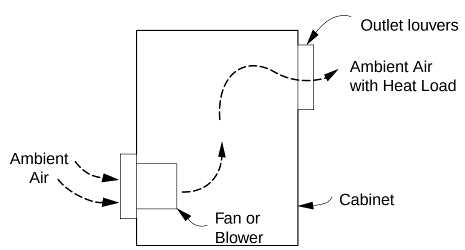
Three Basic Cooling Methods

When selecting a cooling method there are three types to consider.

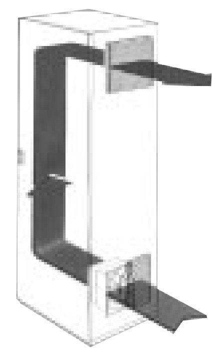
(1) Passive Ventilation - If there is only a minimal heat gain in your circumstance and the ambient air is relatively cool and clean, then the use of louvers or grilles with filters can be effective. This method, however, usually provides less cooling effect than is necessary with today's components. The temperature rise within a sealed enclosure is seen in Figure 2.

(2) Forced Convection Air Cooling - If the installation will be in a clean, non-hazardous environment with an acceptable ambient (outside the enclosure) temperature range, a simple forced-air cooling system utilizing outside air is usually adequate. Combined with an air filter, such devices generally meet the heat removal needs of typical electronic equipment and many electrical applications (Fig. 1). Examples of forced convection air cooling are filter fans, pagoda roof fans, fan trays, and blowers of various types.

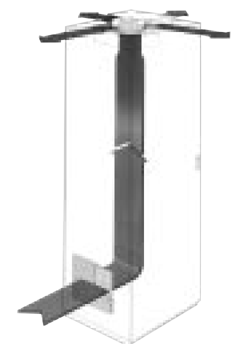
FIGURE 1 - Forced Convection Method



Pressurized System - pushes air through enclosure



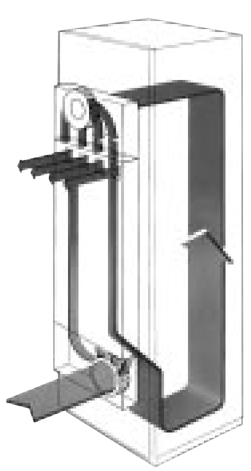
Filter Fan Airflow



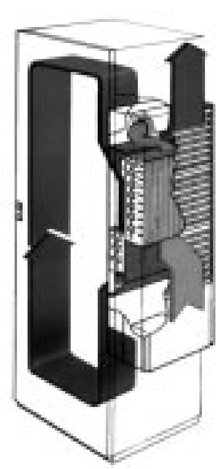
Pagoda Roof Fan Airflow

Fans And Blowers Can Be Used To Pressurize (Preferred) Or Exhaust Cabinet Air. The Ambient Air Should Be Filtered Before It Enters The Cabinet.

(3) Closed-Loop Cooling - In harsh environments involving high temperatures, wash-down requirements, heavy particulate matter or the presence of chemicals capable of damaging components (NEMA 4 or 12 environments), ambient air must be kept out of the enclosure. Closed-loop cooling consists of two separate circulation systems. One system, sealed against the ambient air, cools and recirculates the clean cool air throughout the enclosure. The second system uses ambient air or water to remove and discharge the heat. Examples of closed-loop cooling equipment employed with electronics and process controls are heat exchangers and air conditioners. Blowers are used in higher static pressure applications (when internal equipment is densely packed), and are at maximum efficiency when operating near their peak static pressure.



Air/Air Heat Exchanger Airflow



Air Conditioner Airflow

Climate Control

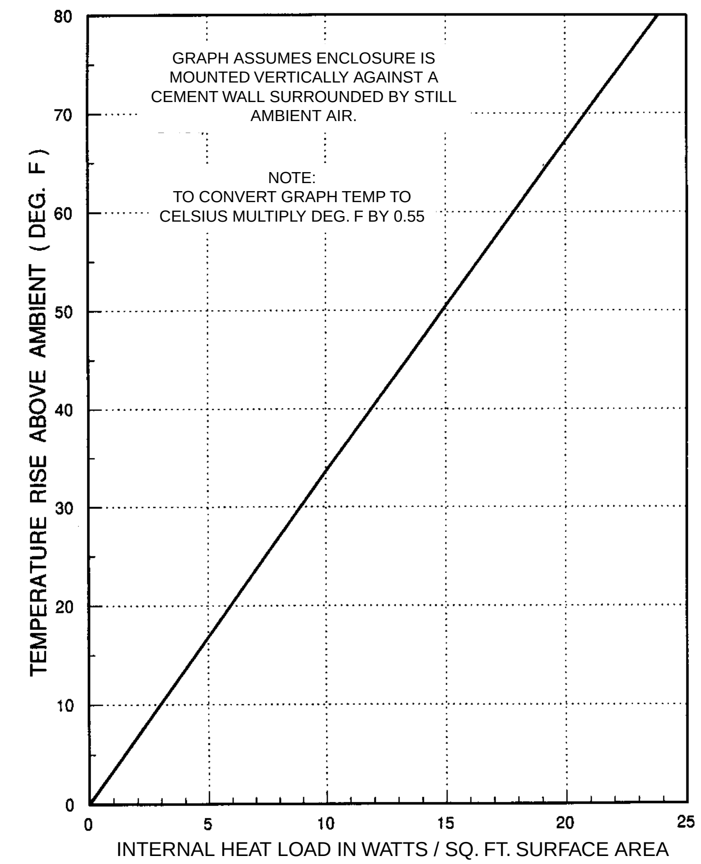
Technical Information

This temperature graph was developed through empirical testing using several enclosures of various sizes.
The temperatures represent an average of one temperature measurement near the bottom of the enclosure and a second measurement near the top. Electric heaters mounted equidistant from the internal surfaces of the enclosure were used as the heat source. Because hot air rises, a significant temperature gradient occurred from top to bottom. Typical of an actual installation, the top was much hotter than the bottom.

The placement of internal parts can affect temperature and enclosures should be sized liberally in applications where temperature rise is critical. Recall that a larger enclosure with twice the surface area reduces the temperature rise by 50%.

Exterior surface finishes significantly influence temperature rise in outdoor applications. For example, painted steel and fiberglass enclosures dissipate heat better than unfinished aluminum enclosures, even though aluminum has superior thermal conductivity, because the colored surfaces of fiberglass and painted steel enclosures are more efficient thermal radiators than unfinished aluminum. Painted surfaces have an emissivity of 0.96 whereas an unfinished aluminum surface has an emissivity of 0.45. In outdoor applications light colored enclosures have a high reflectance which minimizes solar heat gain while dissipating internally generated heat at about the same rate as a similar size dark colored enclosure.

FIGURE 2. - Internal Temperature Rise vs. Internal Heat Load



Climate Control

Technical Information

Additional Cooling Methods

When it has been determined that the heat load is too large for an enclosure to dissipate by radiation and convection, the following supplemental cooling methods are available:

Louvers And Special Ventilation Slots

Louvers and special ventilation slots are designed to remove heat from the enclosure by allowing natural air circulation around the heat source and exhausting the hot air through slots or louvers. This method is relatively inexpensive and has no operating cost; however, it can only be used to dissipate a limited amount of heat and it is difficult to predict the temperature drop produced by a vent utilizing natural convection. This method should not be used in areas where contaminants will enter the enclosure.

Circulating Fans

In larger sealed enclosures, a fan can be used to circulate the air and reduce localized heat concentrations; however, the applications are limited because a closed system fan only redistributes heat, it does not remove the heat generated by the hot spot.

Where an enclosure does not need to be sealed from the outside environment, fans can be used to circulate air through an enclosure and dissipate the heat generated by power supplies, transformers and other heat producing equipment. Fans can provide as much as 10 times the heat transfer rate of natural convection and radiation. Once the heat input in watts/ft^2 is determined and temperature rise is established from Figure 2, the following equation can be used to calculate the fan flow rate:

Fan Flow Rate (cfm) = 3.17 x Internal Heat Load (watts)/Temperature Rise

Example

Equipment in an E 363612 enclosure generates sufficient heat to require a fan which will dissipate 300 watts. The maximum ambient temperature in the application environment is 115°F. If the temperature of the other contents in the enclosure cannot exceed 125°F, what size fan is required?

The allowable temperature rise is 125°F - 115°F = 10°F. The application requires dissipation of 300 watts.

Solution

To determine the cubic feet per minute (cfm) required in a standard application, use the following equation (if the air density is significantly more than 0.075 lbs per cubic foot, a non-standard application exists and this equation should not be used):

Fan Flow Rate (cfm) = 3.17 x 300 watts/10°F

Fan Flow Rate (cfm) = 95 cfm

This calculation is exact, but adding an additional 25% capacity to the level is standard to provide a safety factor.

1.25 x Fan Flow Rate (cfm) =

1.25 x 95 cfm = 119 cfm

If the air density is non-standard (significantly more than 1.075 lb. per cubic foot), the following equation can be used to calculate the fan capacity:

Fan Flow Rate (cfm) x 0.075 lb. per cubic foot / Non-standard Air Density (lb. per cubic foot).

Fans can be used to draw air through an enclosure and exhaust hot air from an enclosure or to draw cool air into and circulate it through an enclosure. An inlet fan offers the following advantages:

- Raises the internal pressure which helps keep dust and dirt out of an unsealed or frequently open enclosure.
- More turbulent air flow improves heat transfer.
- Longer fan life in cooler incoming air.

The following considerations are important in locating a fan:

- Avoid placing transformers, power supplies or other heat generating devices in front of the fan. Although this cools the device, it increases the heat load on other devices within the enclosure. It is best to place these devices near the exhaust outlet.
- To achieve maximum cooling, the inlet and outlet should be separated by the maximum distance. If the outlet and inlet are adjacent to each other, the hot outlet air will be drawn into the inlet and cooling efficiency will be reduced. In general, the inlet should be at the bottom of the enclosure and the outlet at the top.

Climate Control

Technical Information

TECHNICAL APPENDIX

- Fans should not be used or located in areas where the air flow is restricted. A plenum is recommended to accelerate air velocity and improve fan performance. A plenum is particularly helpful when a filter is used where airborne contaminants are a problem.
- The air outlet area should at least equal the inlet area. For best results the exhaust opening should be 1.5 times the area of the fan opening.
- Air is less dense at high altitudes. For this reason air flow should be increased in high altitude applications.
- All fans used in parallel should be identical.

Heat Exchangers - Cooling

Applications requiring sealed enclosures present the greatest need for cooling to maintain safe operating temperatures. Heat exchangers are a good option when precise control of heat and humidity are not required and the heat transfer requirements are significant. The required heat exchanger capacity can be calculated using the formula,

Heat Exchanger Capacity (watts/°C) = (Internal Heat Load T + 5.5w/m^2-C x Enclosure Surface Area x ΔT) where ΔT = Temperature Rise.

Example

If the internal heat load is 1000 watts in an E 603620 freestanding steel enclosure, what is the minimum cooling capacity for the heat exchanger unit? The maximum ambient temperature is 105°F and the internal equipment will malfunction if the internal enclosure temperature exceeds 130°F.

Internal Heat Load = 1000 watts

Maximum Temperature Differential = T_i - T_o =105°F - 130°F = -25°F = -14°C, use Absolute Value.

Enclosure Surface Area = 56.7 ft^2 = 5.3m^2 from Table 1.

Heat Exchanger Capacity = (1000 - 5.5 x 5.3 x 14)/14 = 42w/c

In this example, the surface area acts to cool the enclosure and is subtracted, the Absolute Temperature Value is used because this is a temperature difference.

Air Conditioning - Cooling

Air conditioning will be required in high ambient temperature locations where precise temperature control and humidity reduction are required in a sealed enclosure. Air conditioning can also be required where neither convection, thermal radiation, louvers, slots nor a circulating fan system provide adequate cooling. Because air conditioners remove moisture from the enclosure, a condensate drain is generally required.

The four step process to size and select the air conditioner is influenced by the internal heat load, enclosure size and the application environment. The following information is required:

Step 1. Determine the Internal Heat Load

Heat generated by all sources within the enclosure shall be added together to establish the internal heat load in watts. The heat load in watts may be multiplied by 3.413 to convert to BTU/hr.

Internal Heat Load _____________ watts X 3.413 BTU/hr/watt = ____________ BTU/hr.

Step 2. Calculate the Surface Area of the Enclosure

The enclosure surface area calculation is made in Table 1 using formulas.

The surface area for an enclosure with a height (H = 16 in); a width (W = 20 in); and a depth (D = 8 in); is:

Surface Area = [1.8(16 x 20) + 1.8 (16 x 8) + 1.4 (20 x 8)]/144in^2 = 7.2 ft^2 = 0.67n^2

Using the H, W and D dimensions, select the appropriate formula and calculate the surface area for your enclosure application:

H = _______

W = _______

D = _______

Surface Area = ____________n^2

Step 3. Establish the Temperature Differential

The temperature differential (ΔT) is calculated by subtracting the maximum allowable temperature inside the enclosure (T_i) from the maximum ambient temperature outside the enclosure (T_o).

T_o - T_i = ΔT = _________°C

Step 4. Calculating the Required Air Conditioning Capacity

The values determined in the first three steps are used to calculate the required capacity of the air conditioner according to the following formula,

Cooling Capacity (BTU/hr) = Surface Area x ΔT x K + Internal Heat Load,

where

K = 1.25 BTU/hr/ ft^2 /°F (5.5w/m^2-K) for sheet metal enclosures.

For more information, contact the Rittal Technical Hotline 1-800-637-4425.

Climate Control

Technical Information

Enclosure Heating

Some enclosure systems have minimum as well as maximum operating temperature limitations. When the equipment in an enclosure must be maintained above a minimum temperature at low ambients, these same equations can be modified and used to calculate the supplemental heat required to select and size the heaters. The only differences are that the internal heat load will help heat the enclosure and the temperature difference, ΔT, is calculated by subtracting the minimum ambient temperature (T_o) outside the enclosure from the required temperature (T_i) inside the enclosure. The minimum supplementary heat can be calculated according to one of the following equations:

$\Delta T = T_i - T_o$

Supplementary Heat =
Surface Area x ΔT x K where
K = 0.37 watts/ft² °F.

Example

If the internal heat load is 100 watts in an E 162008 steel enclosure, which is wallmounted, what is the minimum heating capacity for the heating elements? The minimum ambient temperature is 0°F and the internal equipment will malfunction if the internal enclosure temperature drops below 40°F.

$$\Delta T = T_i - T_o = 40°F - 0°F = 40°F$$

=

$$6.27 \text{ ft}^2 \times 40°F \times 0.37 \text{ watts/ft}^2 \, °F = 93 \text{ watts}$$

In addition to heating, supplementary heaters are often used in enclosures to keep the internal enclosure ambient temperature a few degrees above the ambient temperature to prevent condensation on internal equipment.

Equipment for Climate Control

Most cooling or heating requirements can be calculated from the data in this section and the climate control equipment. If you have a problem determining your cooling or heating requirements or selecting the climate control equipment, please contact Rittal.

Rittal's thermal sizing software, Therm 4.0 for Windows, automatically makes calculations for you.

10 Common Pitfalls During Thermal Analysis/Design		
	Pitfall	**Effect**
1.	Underestimating maximum ambient temperature	Undersized cooling device — system failure
2.	Not considering effect of temperature on performance of an air conditioner	Undersized cooling device — system failure
3.	Not derating fan performance for inlet grills, filters, system impedance, etc.	Undersized cooling device — system failure
4.	Not considering convective heat loss or gain	Improperly sized cooling device
5.	Not accurately estimating component heat loss	Improperly sized cooling device
6.	Underestimating component maximum allowable temperature	Oversized cooling device — higher cost
7.	Placing cooling device inlets/outlets too close to obstructions	Reduced performance
8.	Not specifying necessary filters & maintenance schedule for dirty environments	Reduced performance
9.	Not specifying corrosion protection for corrosive environments	System failure
10.	Inadequate warning system in the event of cooling failure	Machine shutdown/system failure

Advantages-At-A-Glance

Air Conditioners

Energy efficient design All Rittal air conditioners come standard with thermostatic expansion valves that operate more efficiently than the expansion devices found on most competitors' units. This can save the end user over $100 per year per air conditioner.

Environmentally friendly technology Our air conditioners come standard with R 134a refrigerant, which is not a CFC or a HCFC. We were the first to convert R 134a and is still the only company with 100% of its product line using this technology.

Reliability/safety Our air conditioners come standard with pressostats helping protect against compressor failure. Evaporator housings are insulated to maximize efficiency and minimize condensation. CE compliances also meet new standards for products exported to Europe.

Low maintenance condensor coils Rittal's wider condensor fin spacing means less likelihood of dirt clogging, and loss of cooling performance.

Long life fans & compressors All Rittal air conditioners come with long-life ball bearing type radial fans. Compressors are thermally protected.

Advanced microprocessor control An advanced microprocessor control option allows you to monitor the performance, pinpoints maintenance needs, and enables remote monitoring.

Installation Rittal's air conditioners are easily and quickly mounted. Terminal blocks offer quick and easy wiring.

Availability/spare parts Rittal has five distribution centers across the U.S., as well as a broad distributor network, for quick access to inventory and spare parts.

Air conditioner repair and disposal Rittal has a repair facility in Springfield, OH. We also offer customers refrigerant recovery and disposal services and on-site repair service.

Broad variety of voltages available Rittal offers 115V, 230V, 400V, and 460V, 50 Hz and 60 Hz air conditioner models.

Special features such as stainless steel housings, environmentallly protected coils, Class 1, Div 2 explosion proof upgrades are available.

Regulatory Compliance We meet global regulatory requirements such as UL, cUL, GS, CE.

Practical Hints

Rittal air conditioners offer the right solution whenever optimum operating conditions inside an enclosure are required. Even with high ambient temperatures is it possible to cool the enclosure's internal temperature down to well below the ambient temperature.

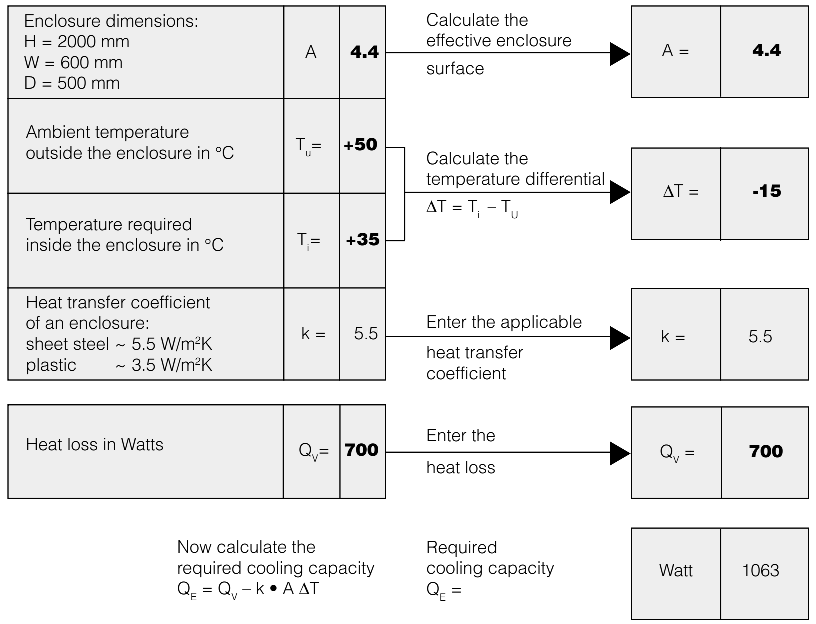
In terms of airflow technology the favorable arrangement of air intake and exhaust openings for the internal and external air circulation loops, ensures optimum air circulation in the enclosure.

The following example shows how to quickly and accurately calculate the specifications for an enclosure air conditioner.

The following should be taken into consideration:

- Where will the enclosure be located (dust or oil-laden air)?
- What type of location is specified per VDE 0660, part 500?
- What conditions must be anticipated (e.g. ambient temperature and humidity)?
- What is the heat loss Q_v in the enclosure?
- What is the max. required interior temperature T_i for the enclosure?
- Is a specific NEMA or IP (per DIN 40 050) protection rating required?
- What voltage is available for air conditioner operation?
- In enclosure suites, it will be necessary to also take into account the heat which may have been absorbed from adjacent enclosures.
- Air conditioners should always be connected via door limit switches to avoid excessive condensation.
- Enclosures and air conditioners should be located and placed so that there is sufficient space for air intake and exhaust.

How To Determine The Sizing For A Wallmounted Air Conditioner, For The Bold Values:



Advantages-At-A-Glance

Air Conditioners

- Air conditioners should be positioned such that air intakes and outlets have at least 8" of clearance from obstructions.
- The enclosure should be sealed to a NEMA 12 standard to avoid condensation.

Condensation and dehumidification of enclosure air when air conditioners are used

When air conditioners are used, dehumidification of the internal enclosure air is an unavoidable side effect. During the cooling process, a part of the moisture in the air condenses at the evaporator and must be removed from the enclosure. The quantity of condensate depends on the relative humidity, the air temperature at the evaporator as well as on the volume of air inside the enclosure.

The diagram on this page (also called the 'Mollier h-x diagram') specifies the amount of water in the air, contingent on its temperature and relative humidity.

Example:

A model 3293100 air conditioner is set at T_i = 35°C. The relative humidity of the ambient air is 70%. The surface temperature of the evaporator is approx. 18°C - the evaporation temperature of the refrigerant. When air of 35°C is blown over the evaporator to be cooled down condensate will form at the surface of the evaporator.
The difference x = x1- x2 indicates how much condensate per kg air would accumulate if the air were completely dehumidified. A deciding factor for the amount of condensate is how well the enclosure is sealed off from its environment.

The volume of condensate can be calculated with the following formula:

$W = V \cdot p \cdot \Delta x$

where:

W= Quantity of water [g]

V= Volume of the enclosure [m³]

p= Density of air [kg/m³]

Δx= Dehumidification [g/kg dry air] per the Mollier h-x diagram

When the enclosure door is closed, only the air within the enclosure will be dehumidified and there will be considerably less condensate than with an open door.

$V = H \cdot W \cdot D = 2\text{ m} \cdot 0.6\text{ m} \cdot 0.5\text{ m}$

$V = 0.6\text{ m}^3$

$W = V \cdot p \cdot \Delta x = 0.6\text{ m}^3 \cdot 1.2\text{ kg/m}^3 \cdot 11\text{ g/kg}$

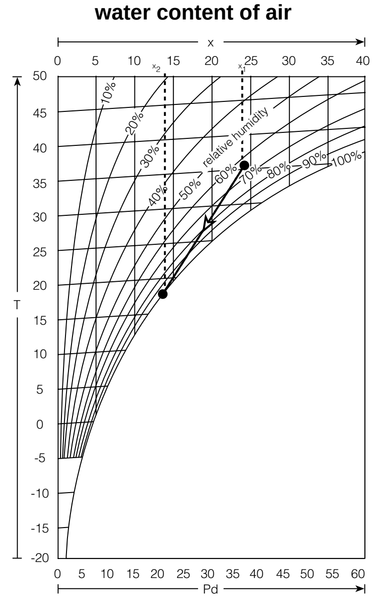
$W = 7.92\text{ g} \approx 8\text{ ml}$

Poorly sealed cable entries, damaged door gaskets, and unsealed installation of display screens etc. on enclosures can cause air leakage from the enclosure to increase. If air was leaking from an enclosure at a rate of only 3 cfm, condensate would accumulate at the rate of 3 oz/h.

Conclusion

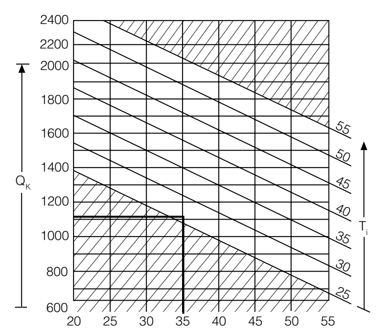
- When the air conditioner is operating the enclosure door should always be closed.
- The enclosure should be sealed on all sides.
- Door switches should be used.
- Air conditioner should meet DIN and EN standards.
- Set temperature only as low as required (Typically 95°F).

Mollier h-x diagram to determine the water content of air



P_d= Partial water-vapor pressure (mbar)
T= Temperature of air (°C)
x= Water content (g/kg dry air)

Performance diagram 3279100/3298100 (DIN 3168) (60 Hz)



T_u= Ambient temperature (°C)
Q_k= Cont. refrigeration capacity (W)
T_i= Internal enclosure temperature (°C)

Sizing For The Air Conditioner

The calculations have specified the required cooling capacity Q_E = 1063 W for an ambient temperature T_U = +50°C and a required interior enclosure temperature T_i = +35°C.

From the available Rittal air conditioners we selected wallmounted model 3298100 with a cooling capacity of 1100 Watt (see performance diagram above).

Advantages-At-A-Glance

Air/Air Heat Exchangers

Reliable and durable All Rittal heat exchangers are known for their durability and long life radial fans.

Easy maintenance They are equipped with filterless operation for quick maintenance with the easily removable cassette.

Installation All Rittal heat exchangers have simple and clean installation, and no mounting flange is necessary.

Special features Although our heat exchangers are lightweight, they are built with very strong construction.

Regulatory compliance Rittal heat exchangers meet global regulatory requirements such as UL, cUL, VDE, CE.

Practical Hints

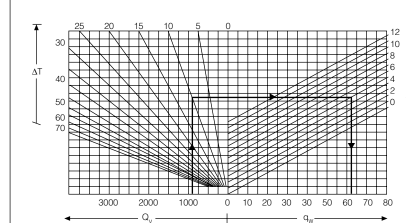
When ambient temperature is considerably lower than the temperature required inside the enclosure, air/air heat exchangers are the climate control component of choice especially if the ambient air contains dust, oil and aggressive chemicals that should not enter the enclosure.

Because of separate interior and exterior air circulation loops, outside air can not enter into the enclosure.

The following should be taken into consideration:

- What ambient temperatures T_u can be expected?
- What is the required interior temperature T_i inside the enclosure?
- What is the total heat loss of components inside the enclosure?
- How much heat, Q_s, is radiated from the inside of the enclosure - through the walls to the environment?
- Is enough space available to install an air/air heat exchanger?

Selection diagram for air/air heat exchangers



ΔT= Temperature differential (K)
Q_v = Heat loss (W)
q_w = Specific heat output (W/K)
A = Enclosure surface per VDE 0660 part 500 (m²)

How To Determine The Sizing For An Air/Air Heat Exchanger, For The Bold Values:

Enclosure dimensions: H = 2000 mm, W = 600 mm, D = 500 mm	A	**4.4**	Calculate the effective enclosure surface	A =	**4.4**
Ambient temperature outside the enclosure in °C	T_u=	**+25**	Calculate the temperature differential $\Delta T = T_i - T_U$	ΔT =	**+10**
Temperature required inside the enclosure in °C	T_i=	**+35**			
Heat transfer coefficient of an enclosure: sheet steel ~ 5.5 W/m²K, plastic ~ 3.5 W/m²K	k=	5.5	Enter the applicable heat transfer coefficient	k =	5.5
Heat loss in Watts	Q_v=	**900**	Enter the heat loss	Q_v =	**900**

Sizing For An Air/Air Heat Exchanger

When the parameters for enclosure surface A, temperature differential ΔT, and heat loss Q_E have been calculated, the required heat exchanger can be determined.

Air/air heat exchanger model SK 3131000 with a specific thermal capacity of 42 W/C most closely meets the requirements.

Now calculate the required cooling capacity

$$q_w = \frac{Q_v - (A \cdot \Delta T \cdot k)}{\Delta T}$$

Required cooling capacity q_w=	W/K	65.8

Advantages-At-A-Glance

Air/Water Heat Exchangers

Reliable and durable All Rittal heat exchangers are known for their durability and long life radial fans.

Safety These air/water heat exchangers are equipped with such safety features as overtemperature alarm contact, solenoid valves, water level sensors, and overflow drainage paths.

Easy maintenance They perform well in dirty or oily environments, without the need to clean filters, cassettes, or coils, and require only 1-2 gal/minute of water.

Special features While the exchangers offer low energy consumption, they also help maintain low capital cost.

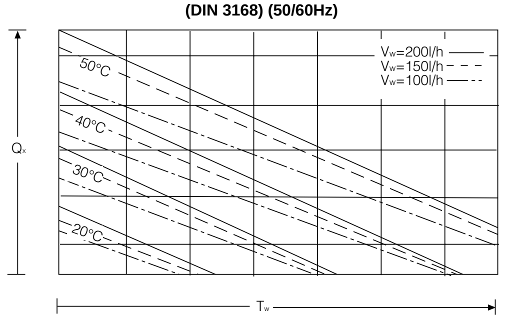
Regulatory compliance Rittal heat exchangers meet global regulatory requirements such as UL, cUL, VDE, CE.

Practical Hints

Air/water heat exchangers offer the greatest cooling performance in the smallest available space.

- With a Rittal air/water heat exchanger, the temperature inside the enclosure can be cooled down to below the ambient temperature.
- They can be used in ambient temperatures up to +158°F (+70°C).
- Air/water heat exchangers are extremely practical in dirty environments.
- Water as warm as 70°F can be used.
- Minimum service required because there are no filters to exchange and there is no direct contact with the ambient air.
- They are available in wall and roof mounted versions.

Performance diagram 3247000
(DIN 3168) (50/60Hz)



T_w= Water entry temperature (°C)
Q_K= Cooling capacity (W)
T_i= Internal enclosure temperature (°C)

How To Determine The Sizing For A Wallmounted Air/Water Heat Exchanger, For The Bold Values:

Enclosure dimensions: H = 2000 mm, W = 600 mm, D = 500 mm	A	**4.4**	Calculate the effective enclosure surface	A =	**4.4**
Ambient temperature outside the enclosure in °C	T_u=	**+50**	Calculate the temperature differential $\Delta T = T_i - T_U$	ΔT =	**-10**
Temperature required inside the enclosure in °C	T_i=	**+40**			
Heat transfer coefficient of an enclosure: sheet steel ~ 5.5 W/m²K, plastic ~ 3.5 W/m²K	k=	5.5	Enter the applicable heat transfer coefficient	k =	5.5
Heat loss in Watts	Q_V=	**1300**	Enter the heat loss	Q_V =	**1300**

Sizing For An Air/Water Heat Exchanger

Because we know that the water temperature is + 10°C and that the water flows at a rate of 200 l/h we have specified a model SK 3247000 air/water heat exchanger with a cooling capacity of 1800 Watt which exceeds the required cooling capacity Q_E = 1542.

Now calculate the required cooling capacity $Q_E = Q_V - k \bullet A\,\Delta T$

Required cooling capacity Q_E =	Watt	1542

Advantages-At-A-Glance

Filter Fans

Regulatory compliance Rittal filter fans meet global regulatory requirements such as UL, cUL, GS, CE.

Special features The air throughput in our filter fans has high cfm in a given size.

Reliability and safety NEMA 12 is achievable when using filter fans.

Installation Rittal's filter fans are easily and quickly mounted with the quick snap-in feature, requiring no screws or tools.

Aesthetics All of the filter fans are available with a thin louver profile.

Broad variety of voltages available Rittal offers 115V, 230V, 24V dc filter fan models to meet the spectrum of global needs.

Environmentally friendly technology Rittal filter fans have a special EMC capability that is available with an off-the-shelf EMI/RFI shielded version.

Practical Hints

When the ambient air is clean and the ambient temperature is considerably lower than the temperature required inside the enclosure, Rittal filter fans should be used to remove heat from inside the enclosure.

The design of the venting louvers of Rittal filter fans ensures unsurpassed stability of air volume as far as pressure loss is concerned; it also provides perfect contact hazard protection against water.

A NEMA 12/13 (IP 54) protection rating can be achieved when a sealing frame and fine filter are used (see accessories).

Installation tips

The way in which filter fans are installed in an enclosure, depends on the way components are installed in the enclosure.

- Filter fans and exhaust filters should be installed on the enclosure so that the air intake is at the bottom and the exhaust is at the top.
- Air flow within the enclosure is reversible: (suction or blowing).
- Since a fan's filter will become dirty in use, always select a larger fan than indicated in the actual calculation.
- Use a fine filter when there are very small dust particles in the air.
- Install a sealing frame and fine filter when you want to increase the NEMA rating.

How To Determine The Sizing For A Filter Fan, For The Bold Values:

Ambient temperature outside the enclosure in °C	T_U =	**+20**	Calculate the temperature differential $\Delta T = T_i - T_U$	ΔT =	**20**
Temperature required inside the enclosure in °C	T_i=	**+40**			
Heat loss in Watts	Q_V=	**800**	Enter the heat loss	Q_V =	**800**
				Watt m³/h	124

h=altitude above sea level (h=0) [m]

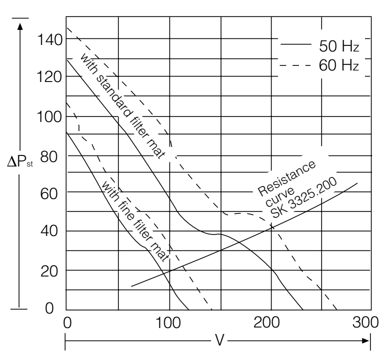
f (0- 100) = 3.1 m³ • K/Wh
f (100- 250) = 3.2 m³ • K/Wh
f (250- 500) = 3.3 m³ • K/Wh
f (500- 750) = 3.4 m³ • K/Wh
f (750-1000) = 3.5 m³ • K/Wh

The following applies for the calculation of the volume of displaced air.

f in this example is 3.1 m³ • K/Wh

$$V = f \bullet \frac{Q_V}{\Delta T} = 3.1 \bullet \frac{800}{20}$$

Performance Diagram
3325115



V= Volume Flow (m³/h)
ΔP_{st}= Stat. pressure difference (Pa)

Sizing For A Filter Fan And Exhaust Filter

We should select a combination of a filter with an exhaust filter that can deliver an air displacement of at least 124 m³/h.

The performance diagram above will help us select the proper combination of filter fan and exhaust filter.

Advantages-At-A-Glance

Panel Heaters

High performance Utilizing PTC technology, the panel heaters operate efficiently with even heat distribution.

Reliability and safety They have a long life expectancy, while their low surface temperature ensures safe operation.

Installation All panel heaters are wired and ready for easy snap-in or screw fastening installation.

Special features Designed to be compact and vibration-free, panel heaters are quite powerful and sturdy.

Regulatory compliance Rittal panel heaters meet global regulatory requirements such as UL, VDE, CE.

Practical Hints

- Maximum efficiency is achieved when enclosure heaters are installed vertically, with the cable entry at the bottom.
- A gap of 2"/50 mm from the top or bottom should be allowed to develop the required convection.
- Heaters should be installed at least .4"/10 mm from steel side walls and at least 1.4"/35 mm from thermo-plastic materials.
- Insofar as possible, heaters should be installed below the components which require protection because hot air rises and will indirectly heat those components.
- In larger enclosures, even heat distribution is best achieved by installing several smaller heaters.
- Heaters can operate without a separate thermostat, but in order to ensure accurate air temperature control within the enclosure, installation of a thermostat is recommended.
- To avoid condensation on installed components, installation of a hygrostat is also recommended.

How To Determine The Sizing For A Panel Heater, For The Bold Values:

Enclosure dimensions: H = 500 mm W = 500 mm D = 300 mm	A	**3.6**	Calculate the effective enclosure surface	A =	**3.6**
Ambient temperature outside the enclosure in °C	T_u=	**+15**	Calculate the temperature differential $\Delta T = T_i - T_U$	ΔT =	**+5**
Temperature required inside the enclosure in °C	T_i=	**+20**			
Heat transfer coefficient of an enclosure: sheet steel ~ 5.5 W/m²K plastic ~ 3.5 W/m²K	k=	5.5	Enter the applicable heat transfer coefficient	k =	5.5

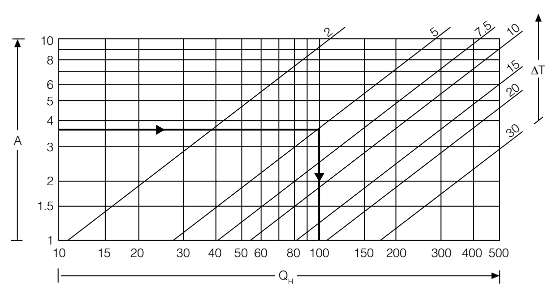
The required heat output can now be calculated with the following formula:

$Q_H = A \cdot \Delta T \cdot k$

$Q_H = 3.6 \cdot 5 \cdot 5.5$

Watt	99 W

Heater performance diagram



Q_H= Required heat output (W)
A= Enclosure surface area per VDE 0660, part 500 (m²)
ΔT= Temperature difference (K)
Based on inside location, static air, heat transfer coefficient k=5.5 W/m² K. For outdoor locations (moving air) the heat output should be doubled.

Sizing For A Heater

Once the values for the enclosure surface and temperature differential are known, the required heat output can be determined from the heater performance diagram.In this case model 3102000 with a heat output of 61 Watt at 10°C was selected.