

# GUIDE SPECIFICATION: MECHANICAL SYSTEMS

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This specification guide includes thermal & acoustical insulation for piping, equipment, vessels, and air handling systems. This section is based on the format recommended by MICA (Midwest Insulation Contractors Association) and has been revised to include K-Flex USA products and installation recommendations. When a project requires more detailed specification statements, one should consult Section 220716 – Plumbing Equipment Insulation, 220719 – Plumbing Piping Insulation, 230716 – HVAC Equipment Insulation, 230719 – HVAC Piping Insulation, 230713 – Duct Insulation, or 233113 – Metal Ducts.

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## PART 1 – GENERAL

### 1.01 SCOPE OF WORK

- A. This specification covers the materials, methods, and installation of thermal insulation for piping, equipment and air handling applications within a temperature range of -40°F to +220°F for the purpose of condensation control, energy savings and noise reduction.

### 1.02 REFERENCES

- A. ASTM (American Society of Testing Materials)
- B. ASHRAE (American Society of Heating, Refrigerating and Air Conditioning Engineers)
- C. SMACNA (Sheet Metal and Air Conditioning National Association)
- D. UL (Underwriter’s Laboratories)
- E. UL GREENGUARD®
- F. NSF (National Sanitation Foundation)
- G. USDA (US Department of Agriculture)
- H. RoHS (Restriction of the use of Hazardous Substances)

### 1.03 DEFINITIONS

- A. UL GREENGUARD® Environmental Institute: Independent testing of products for emissions of Volatile Organic Compounds (VOCs). Provides independent, third-party certification of IAQ performance. Certification is based upon criteria used by EPA, OSHA and WHO.
- B. IAQ: Indoor Air Quality
- C. EPA: Environmental Protection Agency
- D. WHO: World Health Organization
- E. OSHA: Occupational Safety and Health Administration
- F. Thermal Conductivity (K-Value): The amount of heat in Btus transferred in one hour through one square foot of homogenous material one inch in thickness when there is a temperature difference of 1°F. The lower the K Value, the higher the insulating value.
- G. Water Vapor Transmission Rate: The steady water vapor flow in unit time through unit area of a body, normal to specific parallel surfaces, under specific conditions of temperature and humidity at each surface.
- H. Noise Reduction Coefficient (NRC): A single number rating that is the arithmetic average of the individual sound absorption coefficients at 250, 500, 1000 and 2000 Hz to the nearest 0.05.



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#### 1.04 QUALITY ASSURANCE

- A. All insulation recommendations/design criteria are based on products manufactured by K-Flex USA. Exceptions or additions to this specification shall be submitted for written approval by the specifying engineer prior to the bid date. Supporting technical data and samples must be submitted for comparison and review.
- B. Material shall be delivered in non-broken, factory-furnished packaging and stored in a clean, dry indoor space that provides protection against the weather.
- C. Insulation should be applied by qualified personnel skilled in this trade.
- D. Products for indoor installation shall have a flame-spread index of less than 25 and a smoke-developed index of less than 50 when tested to ASTM E 84, latest revision.
- E. Products for outdoor installation shall have a flame-spread index of less than 25 and a smoke-developed index of less than 450 when tested to ASTM E 84, latest revision.

#### 1.05 SUBMITTALS FOR INFORMATION

- A. Product data: To include product description, manufacturer's installation instructions, types and recommended thicknesses for each application, and location of materials.
- B. Samples of systems shall be provided upon engineer's request.

#### 1.06 CODES, REGULATIONS & STANDARDS

- A. Insulation systems, repairs, additions and alterations shall be furnished and installed in accordance with industry standards (ASHRAE / SMACNA) and such statutory provisions (national, state and local codes) as apply to the work under contract. All systems shall be installed according to the manufacturer's recommended practices.
- B. All material shall conform to specified ASTM Standards where applicable, principally ASTM E84 and E2231, and ASTM C534 and C1534.
- C. When applicable, all materials shall conform to UL, USDA, NSF, GREENGUARD®, RoHS or other requirements that are mandated for the application or equipment.
- D. Contractors shall conform to all OSHA and other published practices for the installation of insulation.



## PART 2 - PRODUCTS

### 2.01 INSULATION MATERIALS

#### A. Physical Properties:

1. Insulation shall have a maximum thermal k value of 0.25 BTU - in./hr. - ft<sup>2</sup> - °F when tested according to ASTM C177 or C518 at 75°F mean temperature.
2. Insulation shall have a water vapor transmission rate of 0.01 perm - inch or less when tested according to ASTM E96 (dry cup method).
3. Insulation shall have a maximum water absorption rate of 0.2% (% by volume), when tested in accordance with ASTM C209.
4. Insulation shall have a flame spread of 25 or less and a smoke development rating of 50 or less when tested according to ASTM E84 at the installed thickness for applications inside the building envelope.
5. Insulation materials shall be manufactured without the use of CFCs, HFCs, or HCFCs and also be free of formaldehyde, fibers and dust.
6. Insulation materials shall meet the requirements of ASTM C411.
7. Insulation materials shall meet the requirements of UL 181 for mildew and air erosion, NFPA 90A, and NFPA 90B when used in ducts.
8. Insulation materials shall be UL GREENGUARD® Gold Certified for VOC content.
9. Insulation materials installed indoors that are exposed to food prep or wash down areas shall be NSF-certified to Standard 169, "Special Purpose Food Equipment and Devices".
10. Insulation materials shall be manufactured under the supervision of an independent third party testing program verifying the properties of k (thermal conductivity), wvt (water vapor transmission) and fire performance.

#### B. Flexible Elastomeric: Closed Cell Flexible Elastomeric Foam (FEF) Insulation that complies with ASTM C 534, Type I for tubular material and Type II for sheet material.

1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:
  - a. K-Flex USA; Insul-Tube, Insul-Lock DS, Insul-Sheet, K-Flex HT
2. *Product Recommendations: Recommendations for different applications are as follows:*
  - a. *Pipe Insulation:*
    1. *Pipe ≤ 8" IPS: Insul-Tube, Insul-Lock DS (≤ 4" IPS only). Tube insulation supplied up to 2" wall thickness.*
    2. *Pipe > 8" IPS: Insul-Sheet. Sheet insulation supplied up to 2" thickness.*

- b. *Ductwork (wrap), Vessels, Tanks, & Equipment: Insul-Sheet. Sheet insulation supplied up to 2" thickness. Sheet with factory applied PSA (Pressure Sensitive Adhesive) is available as an option.*
- c. *High Temperature Process Applications: K-Flex HT Tube & Sheet. K-Flex HT is approved for use up to 300 °F and is available in wall thicknesses up to 1". K-Flex HT will have a k-value equal to 0.26 BTU - in./hr. - ft<sup>2</sup> - °F when tested according to ASTM C177 or C518 at 75°F mean temperature.*

## 2.02 HALOGEN FREE INSULATION MATERIALS

- A. Flexible Elastomeric: Closed Cell Flexible Elastomeric Foam (FEF) Insulation that complies with ASTM C534, Type I for tubular material and Type II for sheet material, Grade 3.
  - 1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:
    - a. K-Flex USA; K-Flex ECO

*Note: K-Flex ECO halogen-free insulation (300°F high temperature rating) is recommended for stainless steel surfaces when the operating temperature exceeds 90°F. K-Flex ECO is also recommended for marine applications where compliance with US Navy Spec EB 4013 is required. K-Flex ECO is available in wall thickness up to 1" (ASTM E84 rated up to ¾" thickness).*

## 2.03 ADHESIVES

- A. Flexible Elastomeric Adhesives: For adhering all seams, butts and ends, and adhering sheet insulation to substrates.
  - 1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:
    - a. K-Flex USA; K-Flex Contact Adhesive (373, 320, 420, 620, 720 LVOC, or 1120)
  - 2. *Product Recommendations: Recommendations for different applications are as follows:*
    - a. *Fast Dry Adhesives: K-Flex 320 (Amber Color) or 620 (Black Color)*
    - b. *Comply with MIL-A-24179: K-Flex 373 (Blue Color)*

- c. *LEED Projects: K-Flex 720 LVOC. This adhesive meets the VOC requirements of South Coast Air Quality Management District (SCAQMD) Regulation 1168.*
- d. *High Process Temperature (> 250°F): K-Flex 420*
- e. *Water Based: K-Flex 1120*

## 2.04 FACTORY OR FIELD APPLIED JACKETS

- A. Jacketing shall be either a PVC Composite Jacket (PCJ) or Non-Metallic Polymeric Flexible Jacket (NPJ) in lieu of metal or PVC jacketing:
- B. PCJ shall have a maximum permeance of 0.001 perms when tested according to ASTM E 96 (dry cup method), shall be puncture and dent resistant, shall have a minimum thickness of 0.012", shall have a flame/smoke rating of 25/50 or less when tested according to ASTM E 84 for indoor applications, and shall be NSF-certified for use in food prep or wash down areas.
  - 1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:
    - a. K-Flex USA; K-Flex Clad WT (Indoor or Outdoor applications), K-Flex Clad AL (Outdoor applications only).
- C. NPJ shall have a maximum permeance of 0.08 perms when tested according to ASTM E 96 (dry cup method), shall have a minimum thickness of 0.045", and shall be resistant to UV, chemicals and impact.
  - 1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:
    - a. K-Flex USA; K-Flex Clad IN

## 2.05 TAPES

- A. PCJ Tape: White or aluminum colored tape matching field or factory applied PCJ jacket with rubber based adhesive.
  - 1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:
    - a. K-Flex USA; K-Flex Clad WT Tape, K-Flex Clad AL Tape

2. Width: 2, 4, or 6 inches.
3. Thickness: 0.012 inches.
4. Elongation: 1 percent.
5. Tensile Strength: 90 lbf/in.

## 2.06 INSULATED PIPE SUPPORTS

A. Insulated pipe supports shall be used at pipe hanger locations to prevent the insulation from compressing, shall be comprised of a load-bearing rigid foam insert (high-density urethane or equivalent) with elastomeric foam collars, and shall have a minimum compressive strength of 72 psi.

1. Products: Subject to compliance with requirements, available products that may be incorporated include, but are not limited to, the following:

- a. K-Flex USA; K-Flex 360 Insulated Pipe Support

## PART 3 – EXECUTION

### 3.01 EXAMINATION AND PREPARATION

- A. All insulation work shall be performed by trained personnel regularly engaged in the insulation trade.
- B. Progressive testing of systems to be insulated shall have been completed, inspected and approved by owner's representative before insulation is applied.
- C. Insulation shall not be applied until all surfaces are clean, dry, and free of dirt, grease, moisture or other imperfections. Insulation should not be applied to surfaces that are wet or frosted. Insulation should not be applied to a system that is in operation.
- D. Suitable application temperatures and conditions shall be provided by the Owner and in compliance with the installers design criteria. Installation work shall be performed at the temperatures recommended by the product manufacturer.
- E. All materials, including accessories (i.e. adhesive, coatings, etc.) shall be shipped to the job site in marked, unopened containers as received from the manufacturer. All boxes shall be identified with a manufacturing lot number allowing traceability back to the manufacturing date.
- F. All insulation materials shall comply with specification requirements (material type, thickness and ID).



- G. Insulation shall be protected from moisture and weather during storage and installation. Insulation must be clean and dry prior to installation.

### 3.02 GENERAL INSTALLATION GUIDELINES

- A. Install insulation in accordance with ASTM C1710 and manufacturer's instructions.

### 3.03 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

#### A. Insulation Installation on Piping Systems:

1. Install pipe insulation by sliding non-slit sections over the open ends of pipe when possible or by slitting tubular sections and applying onto piping.
2. Pipe shall be sealed while slipping on insulation to prevent foreign matter from entering the tube. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.
3. All longitudinal seams shall be installed facing down to reduce weight / pressure on the seam.
4. All edges shall be clean cut. Rough or jagged edges shall not be permitted. Proper tools such as sharp, non-serrated knives must be used.
5. All seams, butts and ends shall be completely sealed to retard moisture vapor from entering the system using K-Flex contact adhesive. Do not tape insulation joints.
6. On below-ambient applications, insulation shall be adhered directly to the pipe using a two-inch strip of K-Flex contact adhesive on the ID of the insulation and on the pipe at the following locations: high end of the pipe run, every termination point (supports, valves, flanges, end of pipe run), and every 18 feet of the pipe run.
7. Sheet insulation shall be used on all pipes larger than 8" IPS by wrapping sheet around the pipe and sealing the seams with K-Flex contact adhesive. Insulation shall not be stretched around the pipe.
8. On pipes larger than 12" IPS, insulation shall be adhered directly to the pipe on the lower 1/3 of the pipe.
9. Seams shall be staggered when applying multiple layers of insulation.

#### B. Insulation Installation on Fittings, Valves and Flanges:

1. All fittings (elbows, tees, p-traps, grooved) shall be insulated with the same insulation thickness as the adjacent piping. All seams and mitered joints shall be adhered with K-Flex contact adhesive. Screwed fittings shall be sleeved and adhered with a minimum 1" overlap onto the adjacent insulation.
2. Valves, flanges, strainers and couplings shall be insulated using fabricated insulation pieces that shall then be covered with sheet or oversized tubular insulation.



C. Insulation Installation on Pipe Hangers:

1. K-Flex 360 Insulated Pipe Supports, comprised of high-density rigid foam inserts with elastomeric foam collars, shall be installed at all pipe hanger locations to prevent the insulation from compressing. The pipe support shall have with the same insulation thickness as the pipe insulation. All joints shall be sealed with K-Flex contact adhesive. Saddles shall be installed under all insulated lines at locations where the hanger may move due to movement in the piping from expansion and contraction.

D. Insulation Installation on Exposed Outdoor Piping:

1. All outdoor exposed piping shall be painted with two coats of K-Flex 374 Protective Coating. Prior to applying the Finish, the insulation shall be wiped clean with denatured alcohol. The Finish shall be reapplied every 2-3 years as needed.
2. Alternatively, outdoor insulation may be protected by a field or factory supplied jacket as specified.
3. All outdoor exposed pipe seams shall face downward.

E. Piping Insulation Thickness Schedule:

*Consult local energy code requirements for minimum insulation thickness.*

Minimum Pipe Insulation Thickness for Cooling Systems: ASHRAE 90.1 - 2010

Process Temperature	Nominal Pipe Size				
	<1"	1" to <1.5"	1.5" to <4"	4" to <8"	≥8"
	Insulation Thickness				
<40°F	0.5"	1.0"	1.0"	1.0"	1.5"
40°F to 60°F	0.5"	0.5"	1.0"	1.0"	1.0"

Minimum Pipe Insulation Thickness for Heating Systems: ASHRAE 90.1 – 2010

Process Temperature	Nominal Pipe Size				
	<1"	1" to <1.5"	1.5" to <4"	4" to <8"	≥8"
	Insulation Thickness				
105°F to 140°F	1.0"	1.0"	2.0"	2.0"	2.0"
141°F to 200°F	1.5"	1.5"	2.0"	2.0"	2.0"
201°F to 250°F	2.5"	2.5"	2.5"	3.0"	3.0"

Thickness Schedule to Prevent Condensation on Below-Ambient Piping Systems

*Note: Insulation recommendations are based on data generated using K-Flex USA Insulation Products. Design criteria used to prevent condensation for cold piping systems were for normal **conditions of 85°F (29°C) Ambient and 70% Relative Humidity**. More severe conditions would require additional insulation. Insulation thicknesses must comply with all applicable code provisions. Recommendations below comply with ASHRAE 90.1 – 2010 requirements.*





Piping System	≤1.5"	1.5" to 4"	>4" to 6"	>6"
Chilled water:				
Chilled water (≥40°F)	0.5"	1"	1"	1"
Condensate Drain	0.5"	0.5"	0.5"	0.75"
Refrigeration:				
Above 25°F	0.75"	1"	1"	1"
10°F to 25°F	0.75"	1"	1"	1"
-10°F to 10°F	1"	1"	1.25"	1.25"
-30°F to -10°F	1.25"	1.25"	1.5"	1.5"
<-30°F	Contact K-Flex USA for recommendation.			

F. Insulation Installation on Square and Rectangular Ductwork:

1. Insulation sheet shall be adhered directly to the duct using a minimum of 90% coverage of K-Flex contact adhesive. All surfaces shall be clean and free of dirt, rust, grease, or other impurities. If the surface is not clean, it should be wiped down with a cleaner such as denatured alcohol to ensure good adhesion.
2. Use of sheet insulation with factory-applied PSA (pressure sensitive adhesive) is an acceptable option.
3. The duct shall be insulated using fabricated sheets, not wrapped. The sheets shall be installed such that the top sheet shall overlap the side sheets and the side sheets overlap the bottom sheet to form a water shed, thus ensuring water will not penetrate the seam.
4. Standing metal duct seams shall be insulated with the same insulation thickness as that installed on the duct surface.
5. Transverse joints shall be firmly butted with no gaps and coated with adhesive. Longitudinal corner joints shall be overlapped and compressed.
6. Insulation seams shall be staggered when applying multiple layers of insulation.

*Note: All ductwork shall be tested for air tightness and sealed as necessary prior to installation of duct covering. The use of mechanical attachment for duct covering is optional.*

G. Insulation Installation for Round Ductwork:

1. Sheet insulation shall be used on all round ductwork. Insulation shall be wrapped, not stretched, around the duct. On ductwork larger than 12" in diameter, the insulation shall be adhered to the duct surface on the lower one third.
2. All seams shall be located on the lower half of any round ductwork.
3. All butt and longitudinal joints shall be adhered and sealed with K-Flex contact adhesive.
4. Insulation seams shall be staggered when applying multiple layers of insulation.

H. Insulation Installation on Exposed Outdoor Ductwork:

1. All outdoor exposed ductwork shall be finished via coating, mastic or jacketing to protect against UV and weather.
2. All application methods shall ensure that exterior horizontal surfaces are sloped to prevent water ponding on the surface of the coated insulation. Necessary adjustments



shall be made to create a slope if the substrate is not sloped. Insulation thickness shall not be compromised to achieve the necessary slope.

3. Insulation shall be painted with two coats of K-Flex 374 protective coating. Prior to applying the Finish, the insulation shall be wiped clean with denatured alcohol. The Finish shall be reapplied every 2-3 years as needed.
4. Applications requiring water proofing shall include a mastic application and should be applied according to manufacturer recommendations. Insulation surface must be clean and dry before mastic application.
5. Alternatively, outdoor insulation may be protected by a field or factory supplied jacket as specified. All joints shall be taped using approved tape. Edges of tape shall be sealed with high quality silicone caulking in applications where waterproofing is required. All longitudinal seams shall face downward.

I. Ductwork Insulation Thickness Schedule:

*Note: Insulation recommendations are based on data generated using K-Flex USA Elastomeric Insulation Products. Design criteria used to prevent condensation were for normal **conditions of 85°F Ambient Temperature and 70% Relative Humidity**, unless noted otherwise. More severe conditions would require additional insulation. Insulation thicknesses must comply with all applicable code provisions.*

*Design criteria used for energy savings on hot systems were based on typical energy costs and operating conditions. Energy calculations were based on thickness recommendations which would typically achieve between 20 – 40 BTU loss per hour per square foot. These may not reflect actual conditions and should be verified for each application.*

*ASHRAE 90.1-2010 and most state and local codes determine thickness recommendations (min. R value) based on climate zone and location of the duct i.e. exterior, unconditioned space attic, etc. Minimum R values will range from 1.9 to 8.0 depending on the climate zone and the location of the duct.*

Duct System: (Supply and Return, Outside and Exhaust Air)

System Temperature	Sheet Thickness Recommendation	
Below 0°F	2"	R = 8
0°F to 20°F	1.5"	R = 6
20°F to 40°F	1"	R = 4
40°F to 60°F	0.75"	R = 3
60°F to 100°F	0.5"	R = 2
100°F to 120°F	0.75"	R = 3
120°F to 140°F	1"	R = 4
140°F to 160°F	1.5"	R = 6

J. Insulation Installation on Equipment:

1. Insulation Sheet shall be used to insulate equipment. All surfaces shall be clean and free of dirt, grease and other contaminants, or they should be wiped down with a cleaner such as denatured alcohol. Insulation shall be adhered to the surfaces with full coverage of K-Flex contact adhesive to both surfaces.



2. All seams, butt joints and exposed end cuts shall be adhered with K-Flex contact adhesive. All joints between sheets should be made under compression.
3. Insulation seams shall be staggered when applying multiple layers of insulation.
4. All outdoor exposed equipment shall be finished via coating or jacketing to protect against UV and weather.
5. Insulation shall be painted with two coats of K-Flex 374 protective coating. Prior to applying the Finish, the insulation shall be wiped clean with denatured alcohol. The Finish shall be reapplied every 2-3 years as needed.

K. Equipment Insulation Thickness Schedule:

*Note: Insulation Recommendations are based on data generated using K-Flex USA Elastomeric Insulation Products. Design criteria used to prevent condensation were for normal **conditions of 85°F Ambient Temperature and 70% Relative Humidity**. More severe conditions would require additional insulation.*

*Design Conditions used for energy savings on hot systems were based on typical energy costs and operating conditions. Energy calculations were based on thickness recommendations which would typically achieve a BTU loss of 20 – 40 BTU per hour per square foot. These may not reflect actual conditions and should be verified for each application.*

System Temperature	Sheet Thickness Recommendation
Below 0°F	2"
0°F to 20°F	1.5"
20°F to 40°F	1"
40°F to 60°F	0.75"
60°F to 100°F	0.5"
100°F to 120°F	0.75"
120°F to 140°F	1"
140°F to 160°F	1.5"

**END OF SECTION**

*Items in bold/italics must be completed by the specifying Engineer.*