SECTION 12: DENIS FORMULA - REV #4 - METRIC

SECTION 12

DENIS FORMULA - REVISION #4 - METRIC

12.1 OVERVIEW: DENIS FORMULA

James S. Denis, President of MHG International Inc. based in Calgary, Alberta, first introduced the proposed "Standard Method of Measurement", May 1980 to a World Insulation and Acoustic Congress (W.I.A.C.O.) held in Paris, France.

Later in 1980, the 'Denis Formula' was introduced to major clients in the petro-chemical industry. It quickly gained approval and acceptance as 'fair' to both client and contractor. It is now widely used on industrial projects. Quite apart from the obvious benefit of having one standard method of measurement for the industry, the formula, with ever increasing acceptance and usage, brings economic benefits to the owner.

By identifying and defining the 'labour' intensive portions of the work, with factors to compensate for same, the formula has the balancing effect of reducing 'unit prices'. The prices more properly are based on the straight work where previously they had built-in difficulty factors at time of tendering.

Use of the standard method of measurement (Denis Formula) has eliminated most of the guesswork.

The end result is beneficial to both the owner/client and the insulation contractor. By use of the formula the parties simplify the process of determining the final quantities and value of the work with strict control over the method.

12.2 STANDARD METHOD OF MEASUREMENT FOR INSTALLED INDUSTRIAL INSULATION

These standards are to be used for the express purpose of measuring the quantities of insulation required for a mechanical system. They can be used for tendering, evaluation of bids, and for finalizing accounts.

SCOPE

1. Insulation of mechanical systems including, but not limited to, vessels, equipment, exchangers, pumps, tanks, ducts or flues and pipe work.

2. All measurements shall be taken on the external surface of the insulation system.

3. There shall be no deductions for surfaces not insulated within the specified insulation area. Exceptions to this rule may be negotiated where termination of insulation does not require a finish or weatherproofing and/or where the uninsulated portion is more than 5% of the total.

4. Irregular shapes, fittings on piping systems, valves, etc., shall be counted separately. The conversion tables of the formula are designed to include for general requirements. Conversion factors for unusual items, e.g. seismological anchor or hangers, shall be negotiated by the parties prior to commencing the work.

5. All obstructions and penetrations of the insulation system shall be measured separately.

6. All effected areas and pipe lengths shall be multiplied by the complete applicable unit prices.

DEFINITIONS

Types of insulation: hot, anti-condensation, cryogenic, acoustic, fireproofing.

General description of items to be insulated:

(a) Vessels

Towers, columns, drums, containers, receivers, exchangers, storage tanks, etc.

(b) Equipment

Equipment which has an irregular outer surface, e.g. transitions, stiffeners, heads, roof ends, turbines, pumps, compressors, air or gas handling fans, etc.

(c) Flat Surfaces

Boiler walls, precipitators, hoppers, ducts & flues, storage bins, etc.

(d) Piping

Straight pipes, bends, elbows, accessories, fittings, valves, flanges, strainers, termination points, bevels, etc.

(e) Instruments

Measuring and controlling devices for process requirements.

(f) Height allowances

Standards, see page DF-6.

PRINCIPALS OF MEASURING EQUIPMENT

Shell - Cylindrical

The outside diameter of the vessel plus two times the insulation thickness multiplied by 3.14 and by the length, tangent line to tangent line, as illustrated in diagram. Transition sections (changes in diameter) shall be measured using the larger diameter, times the length. There shall be no deductions for manholes and any other interruption or projection, whether insulated or not.

Irregular Surfaces

Any irregular shape shall be measured on the outside of the insulation surface, using the largest diameter. The surface area for irregular surfaces to be multiplied by a correction factor of 1.75 to obtain the equivalent area of flat surface. For small pumps, turbines, etc. the minimum equivalent area of measurement shall be 1 sq. meter.

Heads, Roofs, Ends

Flat: The surface area with diameter outside of the vessel insulation.

Spherical: The surface area of the hemisphere with diameter outside of the vessel insulation.

Dished: The surface area of a flat circle with a diameter outside of the vessel insulation, multiplied by a correction factor of 1.37.

Cones: The geometrical surface area of the cone, measured outside the insulation thickness.

ADDITIONAL MEASUREMENTS

On "Unit Price" contracts, all insulated nozzles and man-ways connecting to a vessel will be measured as pipe run to the vessel wall plus flange. In addition, all nozzles, man-ways, brackets, platform supports, obstructions, and penetrations, shall have their perimeter measured as irregular surface. All penetrations shall be a minimum 0.1 sq. meter per each.

On "Lump Sum" contracts, where like obstructions, penetrations, nozzles, brackets, supports, stiffener rings, etc. have not been shown in detail on bid drawings, they shall be measured, as above, as extra work to the contract.

PRINCIPALS OF MEASURING

PIPING

Pipe shall be measured from center line to center line through all fittings, in accordance with Diagram 'A', Page 10. All fittings will be counted and classified for multiplication by the appropriate factor listed in the "Fitting Factor Tables" Pages 5 to 8. Fittings connecting two or more different sizes of pipe shall be counted as the largest size involved.

Bent Pipe:

Shall be measured on the outside radius of the bend(s),

Traced Piping:

Insulation sized to accommodate tracer(s) shall be measured at the actual size of insulation used.

Tracer loops shall be measured separately.

12.3 CONVERSION TABLES FOR FITTINGS TO BE ADDED TO LINE TOTAL MEASURED THROUGH ALL FITTINGS

45 Elbows

12.5 mm to 65 mm pipe	0.47	lin. meters of same size & thickness
75 mm to 125 mm pipe	0.62	"
150 mm to 200 mm pipe	0.78	"

225 mm to 300 mm pipe	0.93	"
350 mm to 600 mm pipe	1.24	"
625 mm to 750 mm pipe	1.55	"

90 Elbows

12.5 mm to 65 mm pipe	0.62	lin. meters of same size & thickness
75 mm to 125 mm pipe	0.93	"
150 mm to 200 mm pipe	1.24	"
225 mm to 300 mm pipe	1.55	"
350 mm to 600 mm pipe	1.86	"
625 mm to 750 mm pipe	2.17	"

When stainless steel or FRP jacketing is specified, factors for elbows (with stainless steel or FRP covers), multiply the above tables by 2.5

Bent Pipe multiply length by factor of 3 of same size and thickness

Tracer Loops 0.93 lin. meters minimum, per loop at tracer

(Wrapped Insulation) size by 25 mm (nominal) thickness

Flanges (Pair)

- Hot	0.93	lin. meters of same size and thickness
- Cryogenic	2.17	"
- Anti-condensation	1.24	"

Valve Body (screwed)

12.5 mm to 75 mm	0.62	lin. meters of same size & thickness
100 mm to 200 mm	0.93	"
250 mm and over	1.24	"

Valve Body (welded)

12.5 mm to 75 mm	0.93	lin. meters of same size & thickness
100 mm to 200 mm	1.24	"
225 mm to 300 mm	1.55	"
350 mm to 450 mm	1.86	"

500 mm to 600 mm	2.48	"
650 mm to 750 mm	3.10	"
800 mm and over		measured as equipment

Valve Body (flanged)

12.5 mm to 75 mm	0.62	lin. meters of same size & thickness (+ flanges)
100 mm to 200 mm	0.93	"
225 mm to 300 mm	1.24	"
350 mm to 450 mm	1.55	"
500 mm to 600 mm	1.86	"
650 mm to 750 mm	2.48	"
800 mm and over	3.10	"

Valve Body (with bonnet) Use appropriate factors as above.

12.5 mm to 125 mm	And	0.62	lin. meters to factor (+ bonnet flange)
150 mm to 300 mm	"	0.93	"
350 mm to 500 mm	"	1.24	"
550 mm to 750 mm	"	1.55	"
800 mm to 900 mm	"	1.86	"

Tees .62 lin. meters of same size and thickness

Branch Fittings 0.62 lin. meters of same size and thickness

Reducers, Caps and Termination Points 0.47 lin. meters of same size and thickness

***Hangers (hot)** 0.31 lin. meters of same size and thickness

*Including shoe supports and brackets. Excludes guides and anchors.

Hangers(cryogenic/anti-condensation)

0.31 lin. meters of same size and thickness

Removable Covers multiply fitting factors by 2.5, or a price per cover established by tender.

Screwed / FRP Fittings:

Specified flexible insulation, multiply all factors by 2. Specified preformed or rigid insulation multiply all factors by 3.

Vitaulic Fittings:

These fittings require special consideration because of size and complexity. Therefore the conversion table factors are to be multiplied as follows:

45 Elbows	Multiply factors 3 times
90 Elbows	Multiply factors 3 times
Tees, Fittings:	
12.5 mm to 125 mm	Multiply factors 3 times
150 mm to 300 mm	Multiply factors 5 times
350 mm and over	Multiply factors 7 times

Penetrations:

Items which interfere with the insulation system, e.g., conduits, handrails, ancillary hangers, uninsulated pipe or tubing, etc.

Each cut out 0.62 lin. meters of same size and thickness

When penetrations occur at fittings:

Each cut out 0.93 lin. meters of same size and thickness

Obstructions

Where insulation thickness has to be shaved or cut for walls, sleeves, equipment or other interferences:

Multiply the length of interference by factor of 2

HEIGHT ALLOWANCES

Height Factor Above Grade*

Factor to increase unit price for over 9.2 m height by 10%
Factor to increase unit price for over 12.2 m height by 20%
Factor to increase unit price for over 15.3 m height by 30%
Factor to increase unit price for over 18.3 m height by 40%
Factor to increase unit price for over 21.4 m height by 50%
Factor to increase unit price for up to 24.4 m height by 60%
Factor to increase unit price for over 27.5 m height by 70%
plus 3% per additional meter of height

*Grade does not include working platforms

HOT WORK: (When insulation applied to line in service above 65°C operating temperature)

12.5 mm to 65 mm pipe	increase labour component by	25%
75 mm to 125 mm pipe	"	35%
150 mm to 200 mm pipe	"	45%
225 mm to 350 mm pipe	"	60%
375 mm to 500 mm pipe	"	75%
over 500 mm pipe	"	100%

If labour component has not been identified apply only 50% of the above to the unit prices. These percentages are to compensate for loss of productivity, however safe working conditions shall take precedent.

Imperial Measurement (Conversion)

For equivalent fitting factors multiply computations by 3.28

12.4 EXAMPLE OF PIPING MEASUREMENTS

Pipe Size	25 mm	750 mm
Spec	Hot	Hot
Length of Pipe	32.9 M	92.1 M
Bent Pipe	-	-
45 Elbow	-	4
90 Elbow	16	3
Flanges (Pair)	-	-
Valves (Weld)	-	1
Valves (Flanged)	-	-
Valves (Bonnet)	-	-
Tees	6	7
Reducers or Caps	3	1
Hangers	-	12
Screwed Fittings	13	-
Equivalent Meters	60.04	116.44

SECTION 12: DENIS FORMULA - REV #4 - IMPERIAL

SECTION 12

DENIS FORMULA - REVISION #4 - IMPERIAL

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Use of the standard method of measurement (Denis Formula) has eliminated most of the guesswork.

The end result is beneficial to both the owner/client and the insulation contractor. By use of the formula the parties simplify the process of determining the final quantities and value of the work with strict control over the method.

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INSULATION

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SCOPE

1. Insulation of mechanical systems including, but not limited to, vessels, equipment, exchangers, pumps, tanks, ducts or flues and pipework.

2. All measurements shall be taken on the external surface of the insulation system.

3. There shall be no deductions for surfaces not insulated within the specified insulation area. Exceptions to this rule may be negotiated where termination of insulation does not require a finish or weatherproofing and/or where the uninsulated portion is more than 5% of the total.

4. Irregular shapes, fittings on piping systems, valves, etc., shall be counted separately. The conversion tables of the formula are designed to include for general requirements. Conversion factors for unusual items, e.g. seismological anchor or hangers, shall be negotiated by the parties prior to commencing the work.

5. All obstructions and penetrations of the insulation system shall be measured separately.

6. All effected areas and pipe lengths shall be multiplied by the complete applicable unit process.

DEFINITIONS

Types of insulation: hot, anti-condensation, cryogenic, acoustic, fireproofing.

General description of items to be insulated:

(a) Vessels

Towers, columns, drums, containers, receivers, exchangers, storage tanks, etc.

(b) Equipment

Equipment which has an irregular outer surface, e.g. transitions, stiffeners, heads, roof ends, turbines, pumps, compressors, air or gas handling fans, etc.

(c) Flat Surfaces

Boiler walls, precipitators, hoppers, ducts & flues, storage bins, etc.

(d) Piping

Straight pipes, bends, elbows, accessories, fittings, valves, flanges, strainers, termination points, bevels, etc.

(e) Instruments

Measuring and controlling devices for process requirements.

(f) Height allowances

Standards, see page DF-14.

PRINCIPALS OF MEASURING EQUIPMENT

Shell - Cylindrical

The outside diameter of the vessel plus two times the insulation thickness multiplied by 3.14 and by the length tangent line to tangent line as illustrated in diagram. Transition sections (changes in diameter) shall be measured using the larger diameter, times the length. There shall be no deductions for manholes and any other interruption or projection, whether insulated or not.

Irregular Surfaces

Any irregular shape shall be measured on the outside of the insulation surface, using the largest diameter. The surface area for irregular surfaces to be multiplied by a correction factor of 1.75 to obtain the equivalent area of flat surface. For small pumps, turbines, etc. the minimum equivalent area of measurement shall be 10 sq. feet..

Heads, Roofs, Ends

Flat: The surface area with diameter outside of the vessel insulation.

Spherical: The surface area of the hemisphere with diameter outside of the vessel insulation.

Dished: The surface area of a flat circle with a diameter outside of the vessel insulation, multiplied by a correction factor of 1.37.

Cones: The geometrical surface area of the cone, measured outside the insulation thickness.

ADDITIONAL MEASUREMENTS

On "Unit Price" contracts, all insulated nozzles and man-ways connecting to a vessel will be measured as pipe run to the vessel wall plus flange. In addition, all nozzles, man-ways, brackets, platform supports, obstructions, and penetrations, shall have their perimeter measured as irregular surface. All penetrations shall be a minimum 1 sq. foot per each.

On "Lump Sum" contracts, where like obstructions, penetrations, nozzles, brackets, supports, stiffener rings, etc. have not been shown in detail on bid drawings, they shall be measured, as above, as extra work to the contract.

PRINCIPALS OF MEASURING

PIPING

Pipe shall be measured from center line to center line through all fittings, in accordance with Diagram 'A', Page 10. All fittings will be counted and classified for multiplication by the appropriate factor listed in the "Fitting Factor Tables" Pages 5 to 8. Fittings connecting two or more different sizes of pipe shall be counted as the largest size involved.

Bent Pipe:

Shall be measured on the outside radius of the bend(s),

Traced Piping:

Insulation sized to accommodate tracer(s) shall be measured at the actual size of insulation used.

Tracer loops shall be measured separately.

12.3 CONVERSION TABLES FOR FITTINGS TO BE ADDED TO LINE TOTAL

MEASURED THROUGH ALL FITTINGS

45 Elbows

½” to 2 ½” pipe	1.5	lin. feet of same size and thickness
3" to 5" pipe	2.	"
6" to 8" pipe	2.5	"

9" to 12" pipe	3.	"
14" to 24" pipe	4.	"
25" to 30" pipe	5.	"

90 Elbows

½" to 2 ½" pipe	2.	lin. feet of same size and thickness
3" to 5" pipe	3.	"
6" to 8" pipe	4.	"
9" to 12" pipe	5.	"
14" to 24" pipe	6.	"
25" to 30" pipe	7.	"

When stainless or FRP steel jacketing is specified, factors for elbows (with stainless steel or FRP covers), multiply the above tables by 2.5

Bent Pipe 3 lin. feet of same size and thickness

Tracer Loops 3 lin. feet minimum, per loop at tracer

(Wrapped Insulation) size by 1" (nominal) thickness

Flanges (Pair)

- Hot	3.	lin. feet of same size and thickness
- Cryogenic	7.	"
- Anti-condensation	4.	"

Valve Body (screwed)

½" to 3"	2.	lin. feet of same size & thickness
4" to 8"	3.	"
10" and over	4.	"

Valve Body (welded)

½" to 3"	3.	lin. feet of same size & thickness
4" to 8"	4.	"
9" to 12"	5.	"
14" to 18"	6.	"

20" to 24"	8.	"
26" to 30"	10.	"
32" and over		measured as equipment

Valve Body (flanged)

½" to 3"	2.	lin. feet of same size & thickness (plus flanges)
4" to 8"	3.	" "
9" to 12"	4.	" "
14" to 18"	5.	" "
20" to 24"	6.	" "
26" to 30"	8.	" "
32" to 36"and over	10.	" "

Valve Body (with bonnet) Use appropriate factors as above.

½" to 5"	Add	2.	lin. feet to factors (plus bonnet flange)
6" to 12"	"	3.	" "
14" to 20"	"	4.	" "
22" to 30"	"	5.	" "
32" to 36"	"	6.	" "

Tees 2. lin. feet of same size and thickness

Branch Fittings 2. lin. feet of same size and thickness

Reducers, Caps and Termination Points 1.5 lin. feet of same size and thickness

***Hangers (hot)** 1 lin. feet of same size and thickness

*Including shoe supports and brackets. Excludes guides and anchors.

Hangers(cryogenic/anti-condensation)

2. lin. feet of same size and thickness

Removable Covers multiply fitting factors by 2.5, or a price per cover established by tender.

Screwed / FRP Fittings:

Specified flexible insulation, multiply all factors by 2. Specified preformed or rigid insulation – 3 linear feet per fitting.

Vitaulic Fittings:

These fittings require special consideration because of size and complexity. Therefore the conversion table factors are to be multiplied as follows:

45 Elbows	Multiply factors 3 times
90 Elbows	Multiply factors 3 times
Tees, Fittings:	
½” to 5"	Multiply factors 3 times
6" to 12"	Multiply factors 5 times
14" and over	Multiply factors 7 times

Penetrations:

Items which interfere with the insulation system, e.g., conduits, handrails, ancillary hangers, uninsulated pipe or tubing, etc.

Each cut out 2. lin. feet of same size and thickness

When penetrations occur at fittings:

Each cut out 3. lin. feet of same size and thickness

Obstructions

Where insulation thickness has to be shaved or cut for walls, sleeves, equipment or other interferences:

Multiply the length of interference by factor of 2

HEIGHT ALLOWANCES

Height Factor Above Grade*

Factor to increase unit price for over 30’0" height by 10%
Factor to increase unit price for over 40’0" height by 20%
Factor to increase unit price for over 50’0" height by 30%
Factor to increase unit price for over 60’0" height by 40%
Factor to increase unit price for over 70’0" height by 50%
Factor to increase unit price for up to 80’0" height by 60%
Factor to increase unit price for over 90’0" height by 70%
plus 1% per additional foot of height

*Grade does not include working platforms

HOT WORK: (When insulation applied to line in service above 150°F/65°C operating temperature)

½" to 2 ½" pipe	increase labour component by	25%
3" to 5" pipe	"	35%
6" to 8" pipe	"	45%
9" to 12" pipe	"	60%
14" to 24" pipe	"	75%
25" to 30" pipe	"	100%

If labour component has not been identified apply only 50% of the above to the unit prices. These percentages are to compensate for loss of productivity, however safe working conditions shall take precedent.

Metric Measurement (Conversion)

For equivalent fitting factors multiply computations by .31

12.4 EXAMPLE OF PIPING MEASUREMENTS

Pipe Size	1"	3"	8"	30"
Spec	Hot	Cryog	Hot	Hot
Length of Pipe	108'	78'	200'	302'
Bent Pipe	-	-	26'	-
45 Elbow	-	2	-	4
90 Elbow	16	8	7	3
Flanges (Pair)	-	3	11	-
Valves (Weld)	-	-	-	1
Valves (Flanged)	-	1	2	-
Valves (Bonnet)	-	-	1	-
Tees	6	-	3	7
Reducers or Caps	3	-	1	1
Hangers	-	3	7	12
Screwed Fittings	13	1	-	-
Equivalent Footage	195.5	138.0	365.5	380.5