APÉNDICES

APÉNDICE A-1

CÓDIGO MODELO DE CONSTRUCCIÓN PARA CARGAS DE VIENTO
Association of Caribbean States

Factor de Importancia, I (Cargas de Viento)

Tabla 6-1

Categoría	Regiones No Propensas a Huracán y Regiones Propensas a Huracán con V = 85-100 mph y Alaska	Regiones Propensas a Huracán con V > 100 mph
I	0.87	0.77
II	1.00	1.00
III	1.15	1.15
IV	1.15	1.15

Nota:

1. Las categorías de clasificación de edificaciones y estructuras están listadas en la Tabla 1-1.

Coeficientes de Exposición de la Presión de Velocidad K_h y K_z

Tabla 6-3

Altura por encima del nivel del terreno, z		Exposición (Nota 1)			
		B		C	D
pies	(m)	Caso 1	Caso 2	Casos 1 y 2	Casos 1 y 2
0-15	(0-4.6)	0.70	0.57	0.85	1.03
20	(6.1)	0.70	0.62	0.90	1.08
25	(7.6)	0.70	0.66	0.94	1.12
30	(9.1)	0.70	0.70	0.98	1.16
40	(12.2)	0.76	0.76	1.04	1.22
50	(15.2)	0.81	0.81	1.09	1.27
60	(18)	0.85	0.85	1.13	1.31
70	(21.3)	0.89	0.89	1.17	1.34
80	(24.4)	0.93	0.93	1.21	1.38
90	(27.4)	0.96	0.96	1.24	1.40
100	(30.5)	0.99	0.99	1.26	1.43
120	(36.6)	1.04	1.04	1.31	1.48
140	(42.7)	1.09	1.09	1.36	1.52
160	(48.8)	1.13	1.13	1.39	1.55
180	(54.9)	1.17	1.17	1.43	1.58
200	(61.0)	1.20	1.20	1.46	1.61
250	(76.2)	1.28	1.28	1.53	1.68
300	(91.4)	1.35	1.35	1.59	1.73
350	(106.7)	1.41	1.41	1.64	1.78
400	(121.9)	1.47	1.47	1.69	1.82
450	(137.2)	1.52	1.52	1.73	1.86
500	(152.4)	1.56	1.56	1.77	1.89

Notas:

1. Caso 1: a. Todos los componentes y revestimiento.
   b. Sistema principal resistente a fuerza de viento en edificaciones bajas diseñadas utilizando la Figura 6-10.

   Caso 2: a. Todos los sistemas principales resistentes a fuerza de viento en las edificaciones excepto aquellos en edificaciones bajas diseñado utilizando la Figura 6-10.
   b. Todos los sistemas principales resistentes a fuerza de viento en otras estructuras.

2. El coeficiente de exposición de la presión de la velocidad del viento K_z puede ser determinado a partir de la siguiente formula:

   Para 15 pies $\leq z \leq z_g$ Para $z < 15$ pies

   $K_z = 2.01\ (z/z_g)^{2/\alpha}$ $K_z = 2.01\ (15/z_g)^{2/\alpha}$

   Nota: z no deberá ser tomada menor de 30 pies para el Caso 1 en exposición B.

3. α y z_g se tabulan en la Tabla 6-2.

4. La interpolación lineal para valores intermedios de la altura z es aceptable.

5. Las categorías de exposición están definidas en 4.2.12.

Factor de Direccionalidad del Viento, K_d

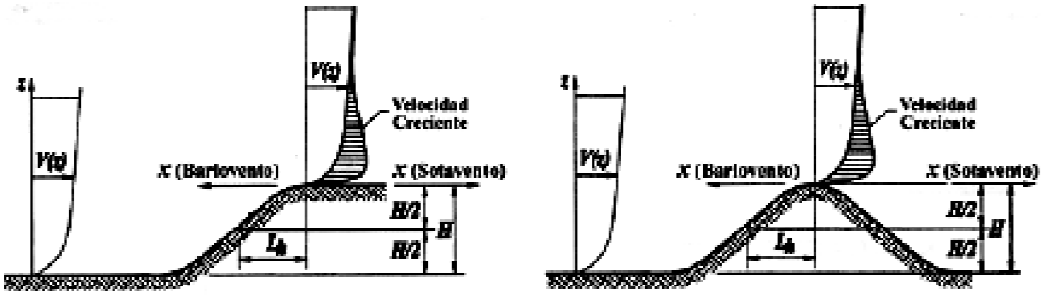
Tabla 6-4

Tipo de Estructura	Factor de Direccionalidad K_d*
Edificaciones	
Sistema Principal Resistente a Fuerza de Viento	0.85
Componentes y Revestimiento	0.85
Techos Arqueados	0.85
Chimeneas, Tanques, y Estructuras Similares	
Cuadradas	0.90
Hexagonales	0.95
Redondas	0.95
Señales Macizas	0.85
Señales Abiertas y Armaduras de Celosía	0.85
Torres de Armaduras	
Triangulares, cuadradas, rectangulares	0.85
Todas las demás secciones transversales	0.95

*El Factor de Direccionalidad K_d ha sido calibrado con combinaciones de las cargas especificadas en epígrafe 3.5. Este factor se aplicará únicamente cuando sea utilizado en conjunto con las combinaciones de carga especificadas en 3.5.1 y 3.5.2.

Factor Topográfico, K_{zt} – Método 2

Figura 6-4



Multiplicadores Topográficos para la Exposición C

H/L_h	Multiplicador K_1			x/L_h	Multiplicador K_2		z/L_h	Multiplicador K_3		
	Cresta 2-D	Talud 2-D	Colina 3-D Axial Simétrica		Talud 2-D	Los Demás Casos		Cresta 2-D	Talud 2-D	Colina 3-D Axial Simétrica
0.20	0.29	0.17	0.21	0.00	1.00	1.00	0.00	1.00	1.00	1.00
0.25	0.36	0.21	0.26	0.50	0.88	0.67	0.10	0.74	0.78	0.67
0.30	0.43	0.26	0.32	1.00	0.75	0.33	0.20	0.55	0.61	0.45
0.35	0.51	0.30	0.37	1.50	0.63	0.00	0.30	0.41	0.47	0.30
0.40	0.58	0.34	0.42	2.00	0.50	0.00	0.40	0.30	0.37	0.20
0.45	0.65	0.38	0.47	2.50	0.38	0.00	0.50	0.22	0.29	0.14
0.50	0.72	0.43	0.53	3.00	0.25	0.00	0.60	0.17	0.22	0.09
				3.50	0.13	0.00	0.70	0.12	0.17	0.06
				4.00	0.00	0.00	0.80	0.09	0.14	0.04
							0.90	0.07	0.11	0.03
							1.00	0.05	0.08	0.02
							1.50	0.01	0.02	0.00
							2.00	0.00	0.00	0.00

Notas:

1. Para valores de H/L_h, x/L_h y z/L_h diferentes a aquellos que se muestran, la interpolación lineal está permitida.
2. Para $H/L_h > 0.5$, asuma $H/L_h = 0.5$ para evaluar K_1 y sustituya 2H por L_h para evaluar K_2 y K_3.
3. Los multiplicadores están basados en el supuesto de que el viento se aproxima a la colina o talud a lo largo de la dirección de la pendiente máxima.
4. Anotación:
   - H: Altura de la colina o talud relativa al terreno de barlovento, en pies (metros).
   - L_h: Distancia a barlovento de la cresta hasta donde la diferencia en la elevación del terreno es la mitad de la altura de la colina o talud, en pies (metros).
   - K_1: Factor para representar la forma de la característica topográfica y el efecto de máximo incremento de velocidad.
   - K_2: Factor para representar la reducción en el incremento de velocidad con la distancia a barlovento o sotavento de la cresta.
   - K_3: Factor para representar la reducción en el incremento de velocidad con altura por encima del terreno local.
   - x: Distancia (a barlovento o sotavento) desde la cresta hasta el sitio de la edificación, en pies (metros).
   - z: Altura por encima del terreno local, en pies (metros).
   - μ: Factor de atenuación horizontal.
   - γ: Factor de atenuación de la altura.

CODIGO ECUATORIANO DE SISTEMAS DE GENERACIÓN CON ENERGÍA SOLAR FOTOVOLTAICA PARA SISTEMAS AISLADOS Y CONEXIÓN A RED DE HASTA 100 KW

TABLA A2. IRRADIACIÓN SOLAR MENSUAL Y PROMEDIO PARA VARIOS SITIOS DEL ECUADOR

Valores en $kWh/m^2.dia$

SITIO	Latitud	Longitud	ELEVACION msnm	AÑOS LECTURAS	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC	PROM.
Ambato	1.28 S	78.63 W	2540	18	4.64	4.56	4.56	4.42	4.39	3.97	4.28	4.5	4.5	4.97	5	4.81	4.55
Babahoyo (I. Maria)	1.82 S	79.55 W	7	18	3.67	3.97	4.36	4.31	3.81	3.25	3.39	3.69	3.78	3.72	3.69	3.72	3.78
Bahia de Caraquez	0.6 S	80.43 W		4	3.88	4.32	4.86	4.49	3.94	3.39	3.83	4.13	4.08	3.68	4.23	4.27	4.09
Baños	1.4 S	78.42 W	843	9	4.25	4.28	3.94	4.11	4.08	3.61	3.89	4.11	4.19	4.75	4.69	4.5	4.2
Boyaca	0.57 S	80.18 W	30	2	3.33	3.36	4.36	3.83	3.67	3.31	3.56	3.94	3.81	4.11	3.94	3.83	3.75
Bucay	2.17 S	79.27 W	317	9	3.22	3.39	3.75	3.5	3.31	2.86	3.28	3.5	3.28	3.42	3.39	3.42	3.36
Camposano	1.58 S	80.4 W	120	2	3.56	3.86	4.36	4.31	4.19	3.53	4.28	4.11	4.28	4.64	4.39	3.89	4.12
Cañar	2.62 S	78.93 W	3104	2	4.47	4.28	4.36	4.28	4.56	4.31	4.92	4.89	4.58	4.78	4.83	4.75	4.58
Cariamanga	4.32 S	79.57 W	1950	2	4.28	4.22	4.36	4.33	4.64	4.81	5.08	5.39	4.67	5.75	5.33	4.64	4.79
Charles Darwin	0.73 S	90.3 W	6	2	4.69	5.03	5.39	5.5	4.53	4.19	3.64	3.53	3.69	4.14	4.36	4.17	4.41
Coca	0.45 S	76.98 W	200	3	3.83	4.53	3.53	4.14	4.14	3.39	3.83	3.83	3.78	4.33	4.25	4.56	4.01
Cotopaxi	0.62 S	78.57 W	3560	2	4.31	4.25	3.94	3.64	3.75	3.86	4.14	4.64	4	4.44	4.56	4.17	4.14
Cuenca-Ricaurte	2.85 S	78.95 W	2562	6	4.58	4.58	4.56	4.28	4.25	3.92	4.22	4.39	4.39	4.78	5.06	4.97	4.5
El Puyo	1.58 S	77.9 W	950	14	3.56	3.56	3.64	3.53	3.69	3.44	3.69	4	4	4.33	4.28	3.89	3.8
Flavio Alfaro	0.4 S	79.6 W	150	1	3.17	3.56	4.06	3.53	3.64	3.31	2.94	3.03	3.28	3.81	3.83	3.75	3.49
Guayaquil	2.2 S	79.88 W	6	9	4	4.17	4.67	4.58	4.56	3.86	4.17	4.5	4.67	4.56	4.31	4.44	4.37
Guayaquil-Aeropuerto	2.2 S	79.88 W		9	3.43	4.41	3.4	4.35	4.32	3.59	4.36	3.63	5.69	4.16	3.72	4.61	4.14
Hacienda Sangay	1.7 S	77.9 W	970	9	3.47	3.47	3.75	3.61	3.69	3.44	3.61	4	4	4.25	4.08	3.81	3.77
Hda. San Vicente	0.57 S	80.43 W		4	3.91	4.23	4.17	4.81	4.05	3.63	2.99	3.18	3.02	3.36	3.17	3.71	3.68
Ibarra	0.35 N	78.13 W		22	4.56	4.38	4.22	4.16	4.35	4.21	4.79	4.93	4.58	4.6	4.37	4.3	4.45
Inguincho	0.25 N	78.4 W	3380	2	4.72	4.92	4.56	4.25	4.47	4.61	4.97	5.08	5	5.03	4.92	4.81	4.78
Isabel Maria	1.8 S	79.53 W		18	3.52	3.83	4.28	4.33	3.62	3.11	3.08	3.41	3.55	3.19	3.24	3.36	3.54
Izobamba	0.37 S	78.55 W	3058	17	4.5	4.44	4.56	4.33	4.64	4.33	5.14	5.06	4.78	4.83	4.75	4.75	4.68
Jama	0.2 S	80.27 W	5	1	3.61	3.64	4.36	3.83	3.75	2.94	4.72	3.44	3.5	4.03	3.94	3.86	3.8
Julcuy	1.47 S	80.62 W	230	3	3.56	3.78	4.25	4.11	4.08	3.44	4.28	4.92	4.5	4.33	4.39	4.11	4.15
La Clementina	1.67 S	79.35 W		8	3.37	3.54	3.81	3.9	3.23	2.74	2.8	3.1	3.34	3.05	3.14	3.43	3.29
La Concordia	0.1 N	79.42 W	300	14	3.5	3.83	4.14	4.06	3.94	3.33	3.69	3.56	3.39	3.47	3.39	3.33	3.64

TABLAS DE LA CONSTANTE K PARA EL CÁLCULO DE LA RADIACIÓN SOBRE SUPERFICIE INCLINADA

VALOR k SEGÚN LATITUD INCLINACIÓN Y MESES DEL AÑO

Latitud: -2º

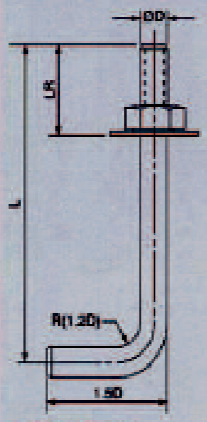
Incli.	ENE	FEB	MAR	ABR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DIC
0	1	1	1	1	1	1	1	1	1	1	1	1
5	0.97	0.98	1	1.01	1.01	1.03	1.02	1.01	1	0.98	0.97	0.96
10	0.93	0.96	0.99	1.02	1.04	1.05	1.04	1.02	0.99	0.96	0.93	0.92
15	0.89	0.93	0.98	1.02	1.05	1.06	1.05	1.02	0.98	0.93	0.89	0.87
20	0.84	0.89	0.96	1.02	1.06	1.07	1.05	1.01	0.96	0.89	0.84	0.82
25	0.78	0.84	0.93	1.01	1.06	1.07	1.04	1	0.93	0.85	0.79	0.76
30	0.72	0.8	0.89	0.99	1.05	1.06	1.03	0.98	0.9	0.8	0.73	0.69
35	0.65	0.74	0.85	0.96	1.03	1.05	1.02	0.95	0.86	0.75	0.66	0.62
40	0.58	0.68	0.81	0.93	1.01	1.03	0.99	0.92	0.81	0.69	0.59	0.55
45	0.51	0.62	0.75	0.89	0.98	1	0.96	0.88	0.77	0.63	0.52	0.47
50	0.43	0.55	0.7	0.84	0.94	0.97	0.93	0.84	0.71	0.57	0.45	0.39
55	0.35	0.48	0.64	0.79	0.9	0.93	0.89	0.79	0.65	0.5	0.37	0.31
60	0.27	0.4	0.57	0.74	0.85	0.88	0.84	0.74	0.59	0.42	0.29	0.23
65	0.19	0.32	0.5	0.68	0.8	0.84	0.79	0.68	0.53	0.35	0.2	0.14
70	0.11	0.24	0.43	0.61	0.74	0.78	0.73	0.62	0.46	0.27	0.13	0.12
75	0.11	0.16	0.36	0.57	0.68	0.72	0.67	0.56	0.39	0.19	0.12	0.11
80	0.1	0.1	0.28	0.47	0.61	0.66	0.61	0.49	0.31	0.13	0.11	0.1
85	0.09	0.09	0.2	0.4	0.54	0.59	0.54	0.42	0.24	0.12	0.11	0.1
90	0.08	0.08	0.12	0.32	0.47	0.52	0.47	0.35	0.16	0.11	0.1	0.09

APÉNDICE A-3

ELEMENTOS NORMALIZADOS

PERNOS DE ANCLAJE EN L

TIPO L.U.



MATERIALES:
Perno anclaje ASTM a 307, grado B.
ROSCA: UNC, clase 2A.
REFERENCIA: Anclaje en L.

TIPO L.U.

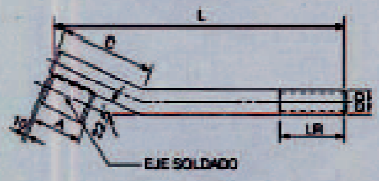
Diámetro	A - LR	L	Peso Teórico Kg.
9.52	45	250	0.3
12.70	55	300	0.4
15.88	65	350	0.7
19.05	70	400	1.1
22.23	100	360	1.27
25.40	80	430	3.1
31.75	80	450	4.2
34.93	80	450	4.23
41.28	80	450	6.16
47.63	80	450	8.5
57.15	80	450	12.54
63.50	80	450	15.88
69.85	80	450	19.75
82.55	80	450	28.76
88.90	80	450	33.7
101.60	80	450	48.51

EJEMPLO: Denominación de un perno de anclaje en L.

L U2 - D - A - L

- L → TIPO DE PERNO
- U2 → CON DOS TUERCAS Y ARANDELA
- D → DIAMETRO
- A → LONGITUD DE ROSCA
- L → LONGITUD DE EJE

TIPO L.F.



TIPO L.F.

Referencia	DIAMETRO	DIMENSIONES EN m.m.			
	D	L	C	LR	EJE SOLDADO
LFU-24-500	24	500	80	90	Ø24 x 90 mm.
LFU-30-500	30	500	80	90	Ø30 x 70 mm.
LFU-42-1000	42	1000	125	150	Ø42 x 115 mm.
LFU-64-2500	64	2500	200	250	Ø64 x 150 mm.

Denominación:
Anclaje en L de diámetro x longitud y especificaciones del material.

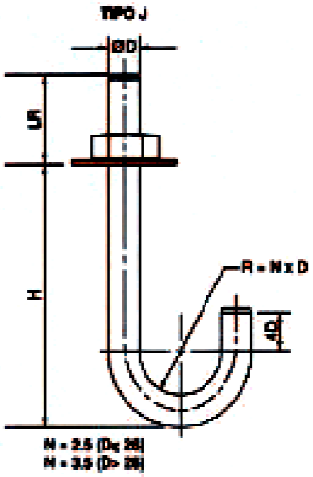
EJEMPLO: Anclaje en LFU-24-500, ASTM o AS325.
El suministro se hace con 2 tuercas y arandela.

LF U2 - 24 - 500

- LF → TIPO DE PERNO
- U2 → CON DOS TUERCAS Y ARANDELA
- 24 → DIAMETRO
- 500 → LONGITUD

forjas bolivar s.a.
CALIDAD FORJADA PIEZA POR PIEZA.

PERNOS DE ANCLAJE EN J



MATERIAL:
ASTM- A-307, grado B.
Otras dimensiones no estipuladas también pueden ser fabricadas.

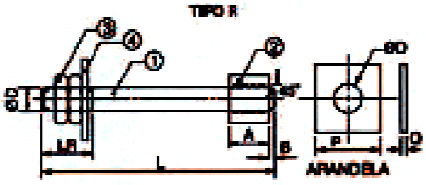
TIPO J

Referencia	DIAMETRO		PESO DEL PERNO EN Kg			
	D	H	LR=75	LR=110	LR=150	LR=200
JU2-10-LR-380	9.52	380	0.305	0.338	0.362	0.382
JU2-12-LR-380	12.7	380	0.402	0.523	0.558	0.603
JU2-16-LR-380	15.87	380	0.730	0.772	0.820	0.881
JU2-16-LR-400	15.87	400	1.00	1.056	1.119	1.198
JU2-19-LR-400	19.05	400	1.306	1.377	1.467	1.597
JU2-19-LR-420	19.05	420	1.711	1.797	1.896	2.019
JU2-22-LR-460	22.2	460	2.247	2.351	2.471	2.620
JU2-25-LR-460	25.4	460	2.745	2.870	3.012	3.189
JU2-28-LR-580	28.57	550	3.788	3.946	4.136	4.351
JU2-32-LR-510	31.75	510	5.255	5.449	5.670	5.949
JU2-32-LR-580	31.75	580	6.982	7.177	7.446	7.782
JU2-35-LR-580	34.92	580	8.701	8.981	9.301	9.700
JU2-38-LR-630	38.1	630	11.019	11.348	11.733	12.192
JU2-41-LR-650	41.27	650	13.400	13.700	14.215	14.759
JU2-44-LR-690	44.45	690	16.330	16.767	17.267	17.891
JU2-50-LR-690	50.8	690	19.691	19.589	20.157	20.867
JU2-50-LR-770	50.8	770	24.929	25.129	25.790	26.623
JU2-57-LR-820	57.15	820	30.375	31.062	31.825	32.792
JU2-60-LR-880	60.32	880	37.356	38.042	38.930	40.040
JU2-63-LR-980	63.5	900	44.117	45.001	46.011	47.274

Suministrado con una o dos tuercas según requerimiento.
Denominación: Perno Anclaje en J, referencia JU2, de diámetro 32, longitud de rosca 110 y profundidad de anclaje 510 con 2 tuercas y arandela.

EJEMPLO: J U2 - 32 - 110 - 510
- TIPO DE PERNO
- CON DOS TUERCAS Y ARANDELA
- DIAMETRO
- LONGITUD DE ROSCA
- PROFUNDIDAD

PERNOS DE ANCLAJE RECTOS



PIEZAS PARA EL TIPO R
① PERNO
② RECTANGULO ACOTAMIENTO
③ TUERCA HEXAGONA
④ ARANDELA CUADRADA

MATERIAL: ASTM A-307.

TIPO R

Referencia	DIAMETRO	PESO DEL PERNO EN Kg							
	D	A	B	C	E	L	LR	P	Q
RU2-80-1585	80	160	15	184	80	1585	200	120	10
RU2-72-2810	76.2	150	20	100	57.15	2810	260	200	54

Con dos tuercas y arandela.
Denominación:
Anclaje recto, referencia RU2 de Ø76 y longitud 2810, material.

EJEMPLO: R U2 - 76 - 2810
- REFERENCIA
- CON DOS TUERCAS Y ARANDELA
- DIAMETRO
- LONGITUD

Tubo Estructural: Redondo

ESPECIFICACIONES GENERALES

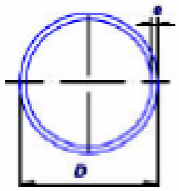
Largo Normal: 6 m
Recubrimiento: Negro o Galvanizado
Dimensiones: Desde 3/4 a 6 plg
20 a 150 mm
Espesores: Desde 1.5 a 6 mm
Calidad del Acero: JIS G3132 SPHT-1
ASTM A 569
Observaciones: Otros dimensiones y largos previa consulta

DIMENSIONES		e	PESO	AREA	PROPIEDADES			
DIÁMETRO EXTERIOR (D)		e	P	A	I	W	i	
Plg	mm	mm	Kg/6m	cm2	cm4	cm3	cm	
3/4	19.05	1.5	3.90	0.83	0.32	0.34	0.62	
		2.0	5.04	1.07	0.39	0.41	0.61	
7/8	22.22	1.5	4.62	0.98	0.53	0.47	0.73	
		2.0	6.00	1.27	0.66	0.59	0.72	
1	25.40	1.5	5.28	1.13	0.81	0.64	0.85	
		2.0	6.90	1.47	1.01	0.80	0.83	
1 1/4	31.75	1.5	6.72	1.43	1.63	1.03	1.07	
		2.0	8.82	1.87	2.08	1.31	1.05	
1 1/2	38.10	1.5	8.10	1.72	2.89	1.52	1.30	
		2.0	10.68	2.27	3.71	1.95	1.28	
1 3/4	44.45	1.5	9.54	2.02	4.67	2.10	1.52	
		2.0	12.54	2.67	6.02	2.71	1.50	
1 7/8	47.63	1.5	10.32	2.17	5.79	2.43	1.63	
		2.0	13.62	2.87	7.48	3.14	1.61	
2	50.80	1.5	10.92	2.32	7.06	2.78	1.74	
		2.0	14.46	3.07	9.14	3.60	1.73	
		3.0	21.24	4.51	12.92	5.09	1.69	
2 3/8	60.33	1.5	13.20	2.77	12.00	3.98	2.08	
		2.0	17.28	3.66	15.66	5.17	2.06	
		3.0	25.44	5.40	22.26	7.38	2.14	
2 1/2	63.50	1.5	13.74	2.92	14.05	4.42	2.19	
		2.0	18.18	3.86	18.29	5.76	2.18	
		3.0	26.88	5.70	26.15	8.24	2.14	
3	76.20	1.5	16.56	3.75	26.10	6.85	2.64	
		2.0	21.96	4.66	32.11	8.43	2.62	
		3.0	32.52	6.90	46.28	12.15	2.59	
4	101.60	2.0	29.46	6.26	77.63	15.28	3.52	
		3.0	43.74	9.29	113.04	22.25	3.49	Nuevo!
		4.0	57.78	12.26	146.28	28.80	3.45	
5	127.00	4.0	72.60	15.46	292.61	46.08	4.35	Nuevo!
		5.0	90.00	19.16	357.14	56.24	4.32	
6	152.40	5.0	112.75	11.97	629.54	82.62	5.21	Nuevo!
		6.0	135.30	14.36	740.57	97.19	5.18	

NORMA INTERNA

Tolerancias:
ø 3/4 - ø 1 3/4 ± 0.50% diámetro nominal
ø 1 7/8 - ø 3 ± 0.75% diámetro nominal
Variación Longitud: +0 mm
-10 mm
Rectitud: 0.4% de longitud (máximo)
Ovalamiento: 1% diámetro nominal (máximo)
Ensayos:
Abocardado: 25% diámetro nominal
Aplastamiento: Total
Doblado: 90° con radio interior mínimo 6 veces el diámetro nominal

APLICACIONES



Usos Estructurales

- Estructuras para invernaderos
- Cerramientos
- Cubiertas espaciales
- Juegos infantiles en plazas y parques
- Pasamanos
- Fabricación de andamios
- Tubos para postes de luz

Otros usos

- Escapes automóviles
- Guardachoques - Mataburros
- Manijas para carretillas
- Canchas deportivas (arcos fútbol, postes volley ball)
- Estructuras para letreros
- Máquinas para gimnasio
- Asientos para vehículos
- Fabricación de maquinaria industrial

NOMENCLATURA

A= Area de la selección transversal del tubo, cm2 W= Módulo resistente de la sección, cm3
I= Momento de Inercia de la sección, cm4 i= Radio de giro de la sección, cm

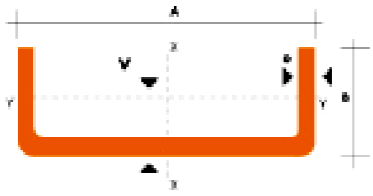
CANALES "U"

DIPAC®
PRODUCTOS DE ACERO

PERFILES ESTRUCTURALES
CANALES "U"

Especificaciones Generales

Otras calidades	Previa consulta
Largo normal	6.00m
Otros largos	Previa consulta
Espesores	Desde 1.50mm hasta 12.00mm
Acabado	Natural
Otro acabado	Previa consulta



DIMENSIONES			PESOS		SECCION	TIPOS						
						EJE X-X			EJE Y-Y			
A	B	e	6metros	1 metro		I	W	i	I	W	i	x
mm	mm	mm	kg	kg	cm2	cm4	cm3	cm	cm4	cm3	cm	cm
40	25	2	7.86	1.31	1.67	4.20	2.10	1.59	1.06	0.62	0.80	0.79
50	25	2	8.82	1.47	1.87	7.08	2.83	1.94	1.13	0.63	0.78	0.72
50	25	3	12.72	2.12	2.70	9.70	3.88	1.89	1.57	0.91	0.76	0.77
60	30	2	10.62	1.77	2.26	12.50	4.16	2.35	2.09	0.93	0.94	0.85
60	30	3	15.54	2.59	3.30	17.50	5.85	2.31	2.84	1.34	0.93	0.89
60	30	4	19.80	3.30	4.20	21.10	7.03	2.24	3.51	1.72	0.91	0.95
80	40	2	14.40	2.41	3.07	30.80	7.71	3.17	4.89	1.68	1.26	1.09
80	40	3	21.24	3.54	4.50	43.90	11.00	3.12	7.01	2.48	1.25	1.14
80	40	4	27.66	4.61	5.87	55.40	13.90	3.07	8.92	3.17	1.23	1.19
80	40	5	34.44	5.74	7.18	65.49	16.37	3.02	10.63	3.83	1.21	1.23
80	40	6	40.44	6.74	8.42	74.18	18.54	2.96	12.10	4.44	1.19	1.28
100	50	2	18.24	3.04	3.87	61.50	12.30	3.99	9.72	2.66	1.58	1.34
100	50	3	26.88	4.48	5.70	88.50	17.70	3.94	14.19	3.89	1.57	1.39
100	50	4	35.22	5.87	7.47	113.00	22.60	3.89	18.16	5.07	1.56	1.44
100	50	5	43.20	7.20	9.18	135.00	27.10	3.84	21.80	6.19	1.53	1.48
100	50	6	51.96	8.66	10.82	155.26	31.05	3.79	25.14	7.24	1.52	1.53
100	60	4	38.28	6.38	8.13	128.00	25.60	3.97	29.70	7.17	1.91	1.86
100	60	5	46.86	7.81	9.96	152.00	30.50	3.91	35.70	8.76	1.80	1.82
100	60	6	57.72	9.62	12.02	181.80	36.36	3.89	42.25	10.38	1.87	1.93
100	60	8	74.40	12.40	15.50	22.60	44.52	3.78	52.47	13.32	1.83	2.06
125	50	2	20.58	3.43	4.37	103.60	16.50	4.86	10.40	2.74	1.54	1.20
125	50	3	30.42	5.07	6.45	149.00	23.90	4.81	15.19	4.02	1.53	1.24
125	50	4	39.60	6.60	8.47	192.00	30.70	4.76	19.40	5.24	1.51	1.29
125	50	5	49.14	8.19	10.40	231.00	37.00	4.71	23.40	6.40	1.50	1.34
125	50	6	59.16	9.86	12.32	266.00	42.87	4.65	27.19	7.51	1.48	1.38
125	60	5	53.82	8.97	11.43	266.98	42.71	4.83	39.36	9.15	1.86	1.70
125	60	6	64.92	10.82	13.52	309.25	49.48	4.78	45.85	10.78	1.84	1.75
125	60	8	84.00	14.00	17.50	383.34	61.33	4.68	57.30	13.94	1.80	1.81
125	80	6	76.44	12.74	15.92	394.28	63.08	4.97	102.94	19.10	2.54	2.61
125	80	8	99.30	16.55	20.69	493.02	78.88	4.88	130.27	24.30	2.50	2.64
125	80	10	120.96	20.16	25.21	576.52	92.25	4.78	154.19	29.31	2.47	2.74
150	50	2	22.92	3.82	4.87	159.00	21.10	5.71	10.90	2.80	1.50	1.09
150	50	3	33.96	5.66	7.20	230.00	30.70	5.65	15.90	4.11	1.49	1.13
150	50	4	44.64	7.44	9.47	297.00	39.60	5.60	20.59	5.36	1.47	1.17
150	50	5	55.02	9.17	11.70	359.00	47.90	5.55	24.80	6.55	1.46	1.22
150	50	6	66.36	11.06	13.82	416.69	55.55	5.49	28.80	7.70	1.44	1.26
150	60	5	59.70	9.95	12.68	441.85	58.91	5.7	41.72	9.40	1.81	1.56
150	60	6	72.12	12.02	15.02	478.93	63.85	5.64	48.70	11.07	1.80	1.60
150	60	8	93.60	15.60	19.50	598.74	79.83	5.54	61.15	14.35	1.77	1.74
150	80	8	93.84	13.04	17.42	603.42	80.45	5.88	109.91	19.73	2.51	2.43
150	80	8	108.90	18.15	22.69	760.23	101.36	5.78	139.53	25.09	2.47	2.44
150	80	10	132.96	22.16	27.71	895.29	119.50	5.68	166.85	30.37	2.44	2.54

También en galvanizado e inoxidable

DIPAC®
PRODUCTOS DE ACERO

TSC

TUBERIA PARA VAPOR

TUBERIA SIN COSTURA Y ACCESORIOS CEDULA 80

Especificaciones Generales

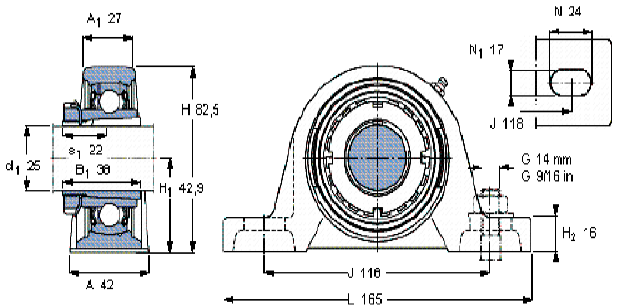
Norma	ASTM - A53 GrB para conducción de fluidos
Recubrimiento	Negro o galvanizado
Largo normal	6.00m
Otros largos	Previa Consulta

	DIAMETRO		ESPESOR		PRESION/PRUEBA		PESO
NOMINAL	EXTERIOR		e	pulg	kg/cm2	lb/pulg2	kg/m
	mm	pulg	mm				
1/4"	13.70	0.54	3.02	0.11	80	850	0.80
3/8"	17.10	0.67	3.20	0.12	80	850	1.10
1/2"	21.30	0.84	3.73	0.14	80	850	1.62
3/4"	26.70	1.05	3.91	0.15	80	850	2.19
1"	33.40	1.31	4.55	0.17	80	850	3.23
1 1/4"	42.20	1.66	4.85	0.19	134	1900	4.47
1 1/2"	48.30	1.90	5.08	0.20	134	1900	5.41
2"	60.30	2.37	5.54	0.21	176	2500	7.48
2 1/2"	73.00	2.87	7.01	0.27	176	2500	11.41
3"	88.90	3.50	7.62	0.30	176	2500	15.27
4"	114.30	4.50	8.56	0.33	197	2800	22.31
6"	168.30	6.62	10.97	0.43	193	2748	42.56

Composición Química	Máximo porcentaje
Carbón	0.3
Manganeso	1.2
Fósforo	0.05
Azufre	0.06

Soportes de pie con rodamientos Y, soporte de fundición, manguito de fijación

Dimensiones					Capacidades de carga		Velocidad	Masa	Designaciones			
					dinámica	estática	límite		Unidad de rodamiento sin manguito	Soporte	Rodamiento	Manguito de fijación
d_1	A	H	H_1	L	C	C_0			de fijacion			
mm					kN		rpm	kg	-			
25	42	82,5	42,9	165	19,5	11,2	6300	0,90	SYJ 30 KF	SYJ 506	YSA 206-2FK	H 2306



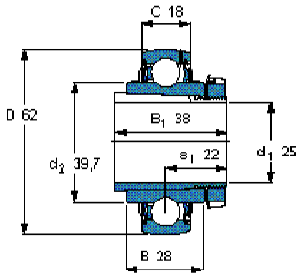
Par de apriete recomendado [Nm]	22..28
Llave de gancho adecuada	HN 6

Rodamientos Y, sobre manguito de fijación

SKF

Tolerancias
Juego radial interno
Tolerancias del eje, ver el texto

Dimensiones principales					Capacidades de carga		Carga límite de fatiga	Velocidad límite	Masa	Designación	
					dinámica	estática				Rodamiento	Manguito de fijacion
d_1	D	B	B_1	C	C	C_0	P_u				
mm					kN		kN	rpm	kg	-	
25	62	28	38	18	19,5	11,2	0,475	6300	0,33	YSA 206-2FK	H 2306



Llave de gancho adecuada
HN 6

Par de apriete recomendado [Nm]
22-28

Aro de asiento de caucho adecuado
RIS 206 A

Factores de cálculo
f_0 14

IBCA
IVAN BOHMAN C.A.

760=ASI 1045
Acero al carbono para maquinaria

GENERALIDADES: Acero al carbono sin alear de esmerada manufactura, con buena tenacidad.
Característica es su alta uniformidad rendimiento. Puede utilizarse en condición de suministro o con tratamiento térmico de temple y revenido. Aplicable a partes relativamente simples de máquinas. Dureza de suministro aproximada: 200 HB

ANÁLISIS TÍPICO %

	C	Si	Mn	P	S
760	0.50	0.30	0.60	–	0.04
AISI 1045	0.43-0.50	–	0.60-0.90	0.040	0.050

EQUIVALENCIAS:

AISI	1045
SAE	C1045
W.Nr	1.1820

DIN	CK45
UDDEHOLM	UHB11

PROPIEDADES MECÁNICAS:

Resistencia a la Tracción	65kg/mm²
Esfuerzo de cedencia	32kg/mm²
Elongación, A5	min 10%
Reducción de area	40%
Dureza	220-235

APLICACIONES:

Componentes sencillos, como por ej:

+ Pernos
+ Chavetas
+ Piezas de mediana resistencia para aplicación automotriz
+ Ejes

TRATAMIENTO TÉRMICO:

Forjado	800-1050 °C
Normalizado	830-850 °C
Temple (agua)	770-810 °C
Temple (aceite)	790-830 °C
Revenido (herramientas de corte)	100-300 °C
Revenido de bonificación	550-650 °C

MEDIDAS EN STOCK

REDONDO

mm	APROX. PULGADAS	PESO APROX. Kg/m
100	4	61.7
115	4 1/2	81.5
125	5	96.3
150	6	139.0
170	6 11/16	178.0
180	7 1/8	199.0
190	7 1/2	222.3
200	7 7/8	250.1
230	9	326.4
250	9 7/8	383.1
305	12 1/64	576.0
330	13 25/32	756.0

Nota: Laminado en caliente

CUADRADO

mm	APROX. PULGADAS	PESO APROX. Kg/m
6x6	1/4x1/4	0.3
8x8	5/16x5/16	0.5
10x10	3/8x3/8	0.8
12x12	1/2x1/2	1.2
16x16	5/8x5/8	2.1
20x20	25/32x25/32	3.2
25x25	1x1	5.0
30x30	1 3/16x1 3/16	7.2
35x35	1 3/8x1 3/8	9.8
40x40	1 9/16x1 9/16	12.6
45x45	1 3/4x1 3/4	15.9
50x50	2x2	19.6
60x60	2 3/8x2 3/8	28.3
70x70	2 3/4x2 3/4	39.0
80x80	3 5/32x3 5/32	50.2
90x90	3 9/16x3 9/16	63.6

Nota: 6x6⇨12x12 Laminado en frio
Resto: Laminado en caliente

IVAN BOHMAN C.A.

KYOCERA

INSTALLATION MANUAL

FOR THE

[redacted]

OF

SOLAR PHOTOVOLTAIC POWER MODULES

Please read this manual carefully before installing the modules.

KYOCERA

60-209565

1. INTRODUCTION

As the world leader in development and application of high technology ceramic/silica materials, Kyocera offers a wide range of highly efficient and reliable crystalline silicon solar photovoltaic (PV) power modules. Kyocera began to extensively research PV technology in 1975 and commenced manufacturing operations in 1978. Since then, Kyocera has supplied millions of cells and modules throughout the world. With years of experience and state-of-the-art technology, Kyocera provides the highest quality PV power modules in a range of sizes designed to meet the requirements of the most demanding energy and power users worldwide.

2. POWER MODULES

Kyocera PV power modules consist of a series of electrically interconnected crystalline silicon solar cells, which are permanently laminated within a polymer and encapsulated between a tempered glass cover plate and a back sheet. The entire laminate is secured within an anodized aluminum frame for structural strength, ease of installation, and to protect the cells from the most severe environmental conditions.

3. APPLICATIONS

Kyocera PV modules are a reliable, virtually maintenance-free direct current (DC) power source, designed to operate at the highest level of efficiency. Kyocera PV modules are ideal to remote homes, recreational vehicles, water pumps, telecommunication systems and many other applications either with or without using storage batteries.

4. WARNINGS & SAFETY

PV modules generate electricity when exposed to light. Arrays of many modules can cause lethal shock and burn hazards. Only authorized and trained personnel should have access to these modules. To reduce the risk of electrical shock or burns, PV modules may be covered with an opaque material during installation. Do not touch live terminals with bare hands. Use insulated tools for electrical connections. Do not use these PV modules for solar concentration.

WARNING

"SUITABLE FOR USE IN CLASS I, DIVISION 2, GROUPS A, B, C AND D HAZARDOUS LOCATIONS, OR NONHAZARDOUS LOCATIONS ONLY."

"WARNING - EXPLOSION HAZARD - DO NOT DISCONNECT EQUIPMENT WHILE THE CIRCUIT IS LIVE OR UNLESS THE AREA IS KNOWN TO BE FREE OF IGNITABLE CONCENTRATIONS."

"WARNING - EXPLOSION HAZARD - SUBSTITUTION OF ANY COMPONENT MAY IMPAIR SUITABILITY FOR CLASS I, DIVISION 2."

PERMIT

- Before installing your PV system, contact local authorities to determine the necessary permitting, installation and inspection requirements.

INSTALLATION AND OPERATION

- Systems should be installed by qualified personnel only. The system involves electricity, and can be dangerous if the personnel are not familiar with the appropriate safety procedures.
- Do not step on a PV module.
- Although Kyocera PV modules are quite durable, the glass can be broken (and PV module will no longer work properly) if it is dropped or hit by tools or other objects.
- PV module frame is made of anodized aluminum, and therefore corrosion can occur if PV module is subject to a salt-water environment and is in contact with another type of metal (electrolytic corrosion). If required, PVC or stainless steel washers can be placed between PV module frame and support structure to prevent this type of corrosion.
- KD series module frames must be attached to a support structure by one of the methods described in Section 7, Installing KD series modules.
- Module support structures to be used to support PV modules should be wind rated and approved by the appropriate local and civil codes prior to installation.
- Do not expose the back of PV module to direct sunlight.
- In Canada installation shall be in accordance with CSA C22.1, Safety Standard for Electrical Installations, Canadian Electrical Code, Part 1.

FIRE RATING

- In case of roof installation, PV module assembly shall be mounted on a fire resistant roof covering rated for the application. KD series modules are comprised of a glass front surface, polyethylene terephthalate (PET) back sheet with a Class C fire rating.

GROUNDING

- Refer to "Grounding" section.

BATTERY

- When PV modules are used to charge batteries, the battery must be installed in a manner which will ensure the performance of the system and the safety of its users. Follow the battery manufacturer's safety guidelines concerning installation, operation and maintenance recommendations. In general, the battery (or battery bank) should be kept away from people and animals. Select a battery site that is protected from sunlight, rain, snow, debris, and is well ventilated. Most batteries generate hydrogen gas when charging, which can be explosive. Do not light matches or create sparks near the battery bank. When a battery is installed outdoors, it should be placed in an insulated and ventilated battery case specifically designed for this purpose.

5. SITE SELECTION

In most applications, Kyocera modules should be installed in a location where they will receive maximum sunlight throughout the year. In the Northern Hemisphere, the modules should typically face south, and in the Southern Hemisphere, the modules should typically face north. Modules facing 30 degrees away from true South (or North) will lose approximately 10 to 15 percent of their power output. If the module faces 60 degrees away from true South (or North), the power loss will be 20 to 30 percent. When choosing a site, avoid trees, buildings or obstructions which could cast shadows on PV modules especially during winter season when the arc of the sun is lowest over the horizon.

6. MODULE TILT ANGLE

Kyocera modules produce bigger power when they are pointed directly at the sun. For stand alone installations PV modules should be tilted for optimum winter performance. As a general rule, if the system power production is adequate in the winter, it will be satisfactory during the rest of the year. PV module tilt angle is measured between PV modules and the ground. Refer to the recommended module tilt angle table for your site.

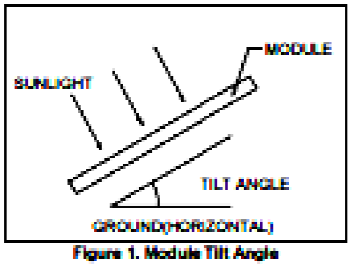


Figure 1. Module Tilt Angle

Figure 5. Installation Example of Cable Clamp

NOTE: MAXIMUM SYSTEM VOLTAGE 600VDC.

KD series modules and most PV system components have a maximum system voltage rating of 600 volts DC. Some grid-tie systems operate at or near this voltage rating. Like other polycrystalline solar modules, the open circuit voltage of the KD series module increases as the ambient temperature decreases. Maximum System voltage is computed as the sum of the open-circuit voltage of the series-connected PV modules for the lowest expected ambient temperature. Refer to the National Electrical Code Article 690-7(a) for determining the maximum number of KD series modules that can be placed in series. Temperature coefficients, specific to the module of use, can be used to provide the most accurate prediction of module voltage under temperature extremes.

NOTE: Install the maximum number of series connection for the KD series PV modules so that the system voltage is less than 600V.

NOTE: In normal conditions, PV modules may produce bigger current and/or voltage than reported in the standard test conditions. Therefore, when voltage evaluations for components, capacity of conductors, size of fuses, and size of control systems connected to the module output are determined, multiply the values of short- circuit current (Isc) and open-circuit voltage (Voc) that are marked in KD series modules by the factor of 1.25. Refer to Section 690-8 of the National Electrical Code for an additional multiplying factor of 1.25 which may also be applicable.

9. GROUNDING

Before installation, contact the local code authorities to determine the necessary grounding requirements. Attach all PV module frames to an earth ground in accordance with the National Electric Code (NEC) Article 250. Proper grounding is achieved by connecting PV module frames and all metallic structural members contiguously to one another using a suitable grounding conductor. The grounding conductor shall be of copper, copper alloy or another material suitable for use as an electrical conductor per NEC. The grounding conductor must then make a connection to earth using a suitable earth grounding electrode. Ensure positive electrical contact through the anodizing on PV module frame extrusion by utilizing one of the following methods. Attach the grounding conductor:

(1)to one of the 9mm (0.35") diameter holes marked "ground" using 5/16" stainless steel hardware. Wrap conductor around bolt. Tighten the screws with adequate torque (usually 132 in-lb). Avoid direct contact of copper ground conductor to aluminum frame.

(2)to a ground lug (manufacture : ILSCO, model : GBL-4DBT). Tighten the screws with adequate torque (usually 62 in-lb). Use #10-32 stainless steel hardware to attach the lug to the module frame by the torque of 40 in-lb. A stainless steel star washer, positioned between the lug and the anodized surface of the frame, must be employed to break through the anodized layer of the frame extrusion and electrically connect the ground lug to the conducting aluminum frame material.

As a general rule, avoid direct contact of copper or copper alloyed ground conductors with the aluminum module frame.

All ground bond securing hardware in contact with either the aluminum module frame and/ or copper or copper alloy ground conductors must be stainless steel.

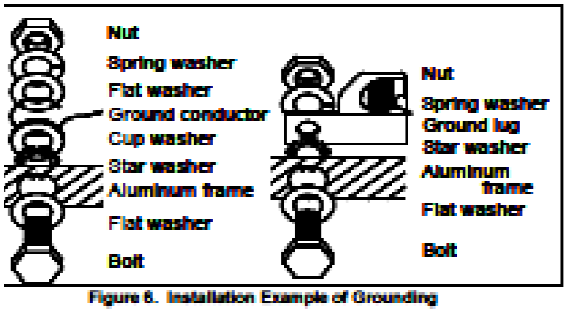


Figure 6. Installation Example of Grounding

10. BLOCKING DIODES

In systems utilizing a battery, blocking diodes are typically placed between the battery and PV module output to prevent battery from discharging at night. Kyocera PV modules are made of polycrystalline cells with high electrical "back flow" resistance to nighttime battery discharging. As a result, Kyocera PV modules do not contain a blocking diode when shipped from the factory. Most PV charge regulators and inverter incorporate nighttime disconnect feature, however.

11. BYPASS DIODES

Partial shading of an individual module in a source circuit string (i.e. two or more modules connected in series) can cause a reverse voltage across the shaded cells within the module. Module output current is then forced through the shaded area by the remaining illuminated cells and other PV modules in series with the partially shaded module(s). The current forced through the shaded cells within PV module (or modules) causes additional module heating and severe loss of power. The purpose of bypass diodes is to provide a low-resistance current path around the shaded cells, thereby minimizing PV module heating and array current losses.

PV modules employ bypass diodes that have:

- Rated Average Forward Current [$I_{F(AV)}$] Above maximum system current at highest PV module operating temperature.
- Rated Repetitive Peak Reverse Voltage [V_{RRM}] Above maximum system voltage at lowest PV module operating temperature.

12. MAINTENANCE

Kyocera PV modules are designed for long life and require very little maintenance. Under most weather conditions, normal rainfall is sufficient to keep the module glass surface clean. If dirt build-up becomes excessive, clean the glass surface only with a soft cloth using mild detergent and water. USE CAUTION WHEN CLEANING THE BACK SURFACE OF PV MODULE TO AVOID PENETRATING THE BACK SHEET. PV modules that are mounted flat (0° tilt angle) should be cleaned more often, as they will not "self clean" as effectively as modules mounted at a 15° tilt or greater. Once a year, check the tightness of terminal screws and the general condition of the wiring. Also, check to be sure that mounting hardware is tight. Loose connections may result in a damaged PV module or array.

13. SPECIFICATIONS

Under certain conditions, a photovoltaic module may produce more voltage and current than reported at Standard Test Conditions (STC). Refer to Section 690 of the National Electrical Code for guidance in series string sizing and choosing overcurrent protection.

Table.2 Kyocera KD Series Module Specification

Electrical Characteristics : @ STC		
Model Type	KD135GX-UPU	KD140GX-UPU
Rated Power, Watts (Pmax) (W)	135 ±5%	140 ±5%
Open Circuit Voltage (Voc) (V)	22.1	22.1
Short Circuit Current (Isc) (A)	8.37	8.68
Voltage at Load (Vpm) (V)	17.7	17.7
Current at Load (Ipm) (A)	7.63	7.91
Maximum System Voltage	600	600
Recommended maximum number of PV modules connected in series	21	21
Factory Installed Bypass Diode (Qty)	6	6
Series Fuse Rating (A)	15	15
Thermal Characteristics :		
Temp. Coefficient of Voc (V / °C)	-0.80×10^{-1}	-0.80×10^{-1}
Temp. Coefficient of Isc (A / °C)	5.02×10^{-3}	5.21×10^{-3}
Temp. Coefficient of Vpm (V / °C)	-9.20×10^{-2}	-9.22×10^{-2}
Physical Characteristics :		
Length, Inches (mm)	59.1 (1500)	
Width, Inches (mm)	26.3 (668)	
Depth (frame), Inches (mm)	1.81 (46)	
Depth (including j-box), Inches (mm)	-	
Weight Pounds (kg)	27.6 (12.5)	
Mounting Hole Diameter, Inches (mm)	0.35 (9) Qty-4pcs	
Grounding Hole Diameter, Inches (mm)	0.35 (9) Qty-4pcs	
Application Class	Class A	

NOTES

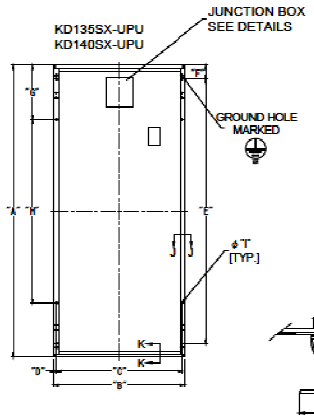
(1) Standard Test Conditions of Irradiance of 1000 W/m^2, spectrum of air mass 1.5, and cell temperature of 25 deg C.

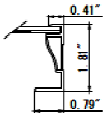
(2) See module drawing for mounting and grounding hole locations.

(3) Tolerance of Voc and Isc is +/-10%.

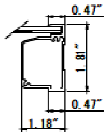
MODULE DRAWING

MODULE DIMENSIONS										
MODULE TYPE	DIM.A	DIM.B	DIM.C	DIM.D	DIM.E	DIM.F	DIM.G	DIM.H	DIM.I	J-BOX TYPE
KD135SX-UPU,KD140SX-UPU	59.1″	26.3″	25.3″	0.49″	53.5″	2.76″	11.0″	37.1″	0.35″	IM

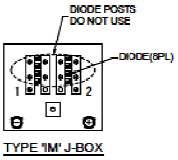




SECTION J-J

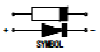


SECTION K-K



TYPE "IM" J-BOX

TERMINAL DESIGNATIONS
1:NEGATIVE POST
2:POSITIVE POST



DIODE DETAIL

APÉNDICE A-3
Solar Position Algorithm
For Solar Radiation Applications
National Renewable Energy Laboratory

C Code: SPA header file (SPA.h)

```
//////////////////////////////////////////
//          HEADER FILE for SPA.C       //
//                                      //
//      Solar Position Algorithm (SPA)  //
//                for                   //
//        Solar Radiation Application   //
//                                      //
//              May 12, 2003            //
//                                      //
//   Filename: SPA.H                    //
//                                      //
//   Afshin Michael Andreas             //
//   afshin_andreas@nrel.gov (303)384-6383 //
//                                      //
//   Measurement & Instrumentation Team //
//   Solar Radiation Research Laboratory //
//   National Renewable Energy Laboratory //
//   1617 Cole Blvd, Golden, CO 80401   //
//////////////////////////////////////////
//////////////////////////////////////////////////////////////////////////
//                                                                      //
// Usage:                                                               //
//                                                                      //
//   1) In calling program, include this header file,                   //
//      by adding this line to the top of file:                         //
//           #include "spa.h"                                          //
//                                                                      //
//   2) In calling program, declare the SPA structure:                  //
//           spa_data spa;                                              //
//                                                                      //
//   3) Enter the required input values into SPA structure              //
//      (input values listed in comments below)                         //
//                                                                      //
//   4) Call the SPA calculate function and pass the SPA structure      //
//      (prototype is declared at the end of this header file):         //
//           spa_calculate(&spa);                                       //
//                                                                      //
//   Selected output values (listed in comments below) will be          //
//   computed and returned in the passed SPA structure.  Output         //
//   will based on function code selected from enumeration below.       //
//                                                                      //
//   Note: A non-zero return code from spa_calculate() indicates that   //
//         one of the input values did not pass simple bounds tests.    //
//         The valid input ranges and return error codes are also       //
//         listed below.                                                //
//////////////////////////////////////////////////////////////////////////

#ifndef __solar_position_algorithm_header
#define __solar_position_algorithm_header

//enumeration for function codes to select desired final outputs from SPA
enum {
    SPA_ZA,           //calculate zenith and azimuth
    SPA_ZA_INC,       //calculate zenith, azimuth, and incidence
    SPA_ZA_RTS,       //calculate zenith, azimuth, and sun rise/transit/set values
    SPA_ALL,          //calculate all SPA output values
};

typedef struct
{
    //----------------------INPUT VALUES-----------------------

    int year;           // 4-digit year,    valid range: -2000 to 6000, error code: 1
    int month;          // 2-digit month,         valid range: 1 to 12,  error code: 2
    int day;            // 2-digit day,           valid range: 1 to 31,  error code: 3
    int hour;           // Observer local hour,   valid range: 0 to 24,  error code: 4
    int minute;         // Observer local minute, valid range: 0 to 59,  error code: 5
    int second;         // Observer local second, valid range: 0 to 59,  error code: 6
    double delta_t;     // Difference between earth rotation time and terrestrial time
                        // It is derived from observation only and is reported in this
                        // bulletin: http://maia.usno.navy.mil/ser7/ser7.dat,
                        // where delta_t = 32.184 + (TAI-UTC) - DUT1
                        // valid range: -8000 to 8000 seconds, error code: 7
    double timezone;    // Observer time zone (negative west of Greenwich)
```