

ProNode™

PRODUCT DESCRIPTION

Zinc alloy anodes are used for the cathodic protection of steel and aluminum alloy structures exposed to seawater, including ship hulls, ballast tanks, heat-exchanger condensers, and piping systems. Compared with aluminum and magnesium anodes, zinc anodes provide a lower driving potential, helping reduce the risk of overprotection, coating disbondment, and hydrogen embrittlement.

Zinc alloy anodes are also suitable for chloride-containing soil environments, including the cathodic protection of prestressed concrete cylinder pipe (PCCP) systems.

PRODUCT FEATURES

Application Versatility

- Suitable for seawater service and chloride-containing soil environments, including PCCP systems.

Custom Engineering Capability

- Zinc alloy anode formulations can be tailored to specific operating temperature ranges and application requirements.



ZINC ALLOY SACRIFICIAL ANODE



PRODUCT PERFORMANCE

Electrochemical Performance

- Lower driving potential helps reduce the risk of overprotection, coating disbondment, and hydrogen embrittlement in high-strength steel.

Standards Compliance & Material Quality

- Manufactured using high-purity zinc raw material (99.995%) and controlled alloying additions, with composition and quality controls in accordance with ASTM B418 and MIL-A-18001K, as applicable.

High-Temperature Performance

- Specially formulated high-temperature zinc alloy anodes are designed for 50 – 80 °C service, maintaining stable potential ≤ -970 mV vs. Ag/AgCl and electrochemical capacity above 770 Ah/kg, without polarity reversal under specified test conditions.

Reference	Title
ASTM B418-16A(2021)	STANDARD SPECIFICATION FOR CAST AND WROUGHT GALVANIC ZINC ANODES
DNV-RP-B401, EDITION 2021-05	CATHODIC PROTECTION DESIGN
EN 12496:2013	GALVANIC ANODES FOR CATHODIC PROTECTION IN SEAWATER AND SALINE SEDIMENTS
NACE RP0196	GALVANIC ANODE CATHODIC PROTECTION OF INTERNAL SUBMERGED SURFACES OF STEEL WATER STORAGE TANKS
NACE SP010	CATHODIC PROTECTION OF PRESTRESSED CONCRETE CYLINDER PIPELINES
NACE SP040	CATHODIC PROTECTION OF REINFORCING STEEL IN BURIED OR SUBMERGED CONCRETE STRUCTURES
EN 16222	CATHODIC PROTECTION OF SHIP HULLS

PRODUCT QUALITY

Strict Manufacturing

Advance Technology ensures the performance and quality stability of its zinc alloy sacrificial anodes through strict raw material quality control and casting processes.

Raw material purity directly affects impurity levels and the accuracy of the final zinc alloy anode composition, both of which are critical to anode performance. We use high-purity zinc raw materials and controlled alloying additions, and each batch is inspected, accepted, identified, and stored in accordance with applicable quality control requirements.

In addition to precise control of each alloying element, the casting parameters of zinc alloy sacrificial anodes, including pouring temperature, mold temperature, holding time, and cooling control, have a significant impact on the anode microstructure. This microstructure, including element distribution and grain size, directly affects anode performance and dissolution behavior.

The above images compare the dissolution morphology of zinc alloy sacrificial anodes with the same nominal composition, produced using a controlled casting process and a rough casting process, respectively, with reference to DNV-RP-B401 Appendix B where applicable. Finer, more uniform grains and denser grain packing achieved through controlled casting help produce more uniform dissolution morphology.

During long-term service, zinc alloy anodes with uneven dissolution morphology may experience localized corrosion, premature material detachment, and reduced utilization. Advance Technology’s controlled casting process helps reduce these risks and supports stable, consistent anode performance.

Standardized Process

Advance Technology has established a strict quality management system in accordance with ISO 9001. For zinc alloy sacrificial anodes, we implement comprehensive quality control procedures, including:

- Manufacturing Process Specification (MPS)
- Inspection and Test Plan (ITP)
- Production Record Sheet

These procedures are developed in accordance with customer requirements and project specifications, and are verified through pre-production qualification testing (PQT) before full production to ensure consistent anode performance and quality.

Customized Inspection

Inspection and testing of Advance Technology zinc alloy sacrificial anodes are performed in accordance with applicable international standards, including DNV-RP-B401, EN 12496, and NACE SP0387, as well as customer requirements and project specifications. Chemical composition and electrochemical performance testing may be performed using samples taken from the melt at the start, middle, or end of each heat, or from finished anodes. Physical inspection and testing may be performed by batch sampling or 100% inspection, depending on project requirements.

TECHNICAL INNOVATION

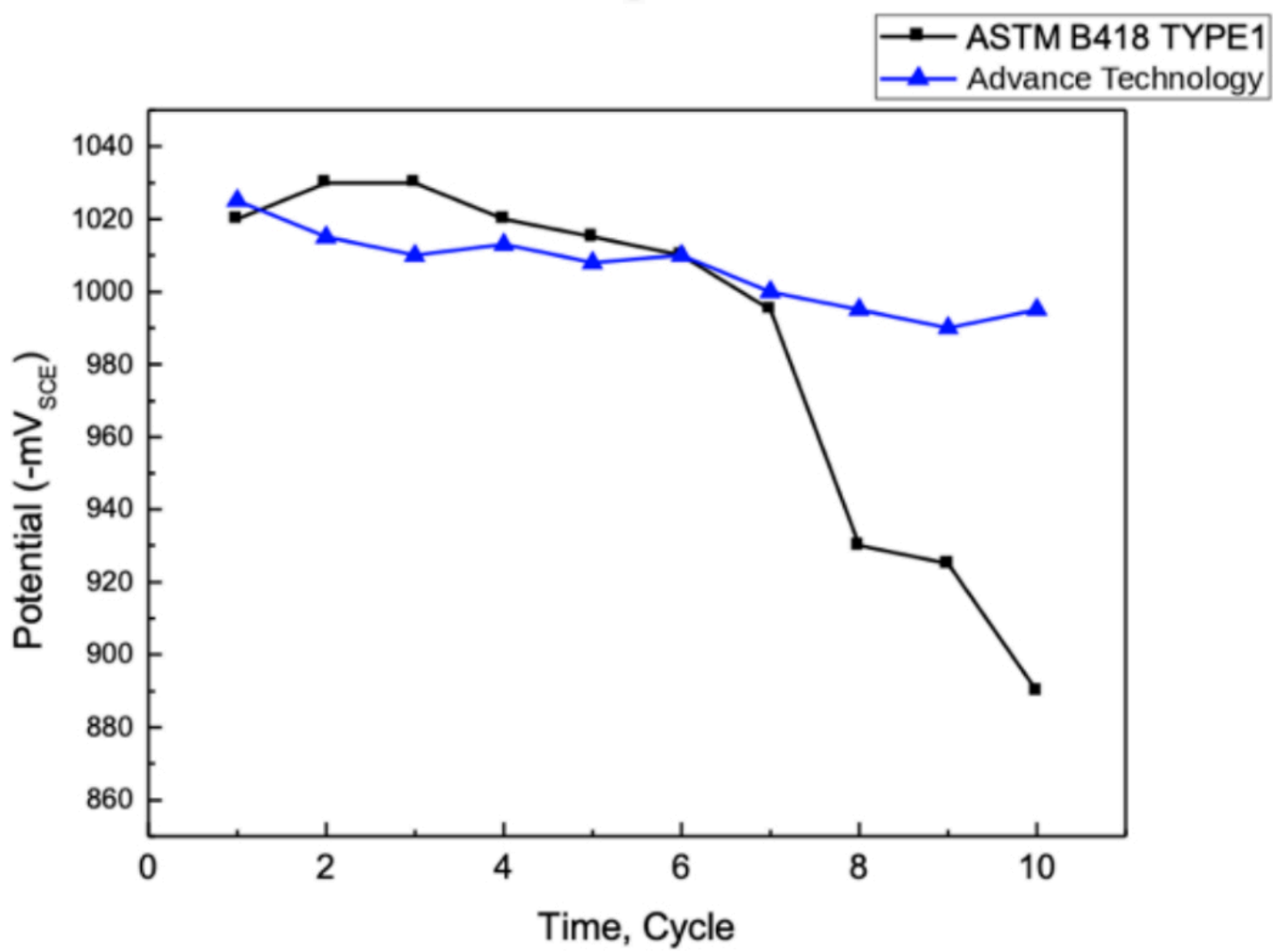
Advance Technology offers a wide range of zinc alloy sacrificial anode products and develops application-specific solutions for different project requirements and service environments.

Marine Zinc Alloy Anode

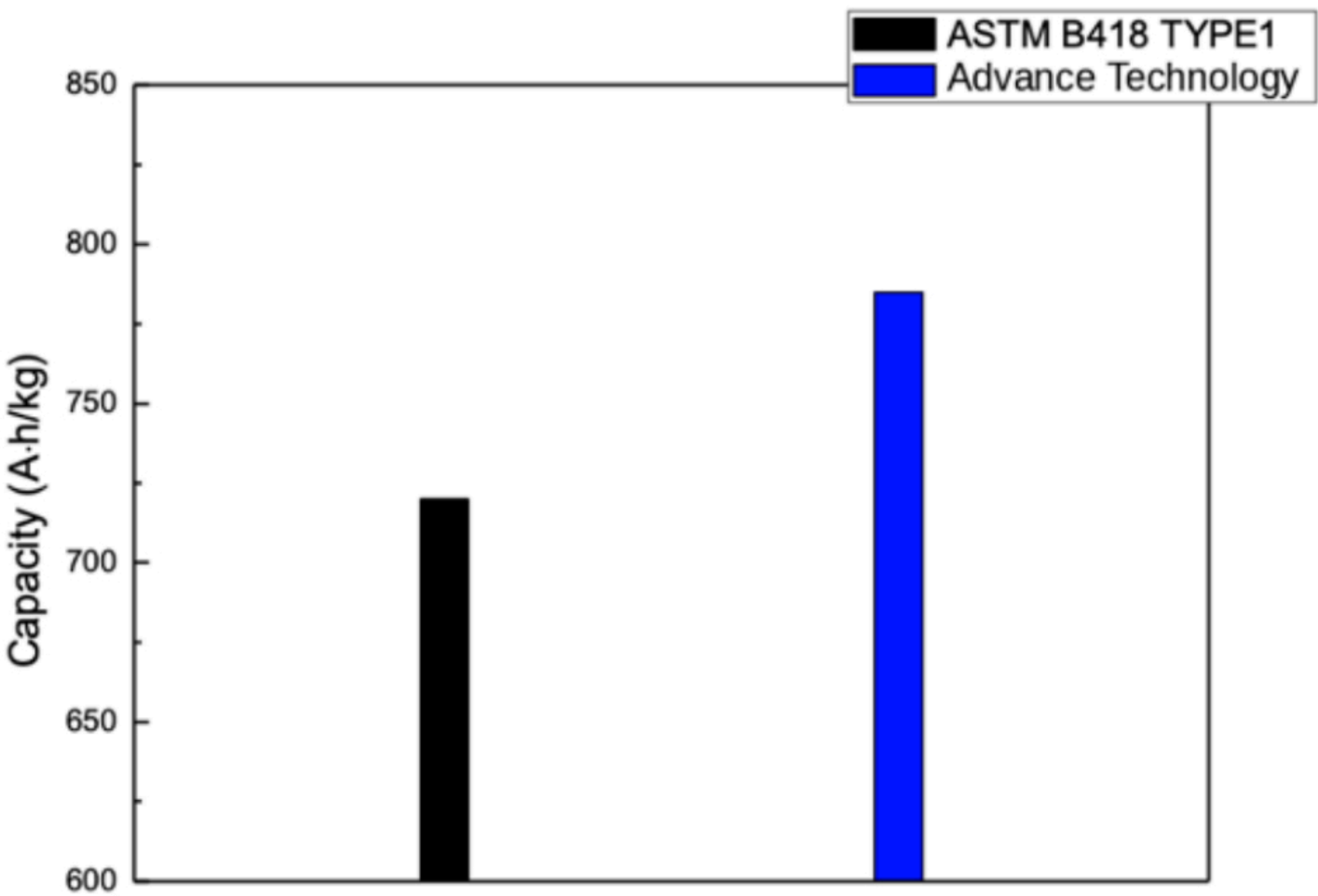
As marine technology advances, high-strength steel is being used more widely, and corrosion control requirements are becoming increasingly stringent. Overprotection during cathodic protection of high-strength steel may induce hydrogen embrittlement, reducing toughness and ductility and potentially compromising structural integrity. Compared with other sacrificial anode materials, zinc alloy sacrificial anodes have a more positive closed-circuit potential and can help regulate protection current, reducing the risk of overprotection and hydrogen embrittlement when correctly selected, designed, and installed. Zinc alloy sacrificial anodes are also commonly selected for certain oil tanker applications where low spark risk and project requirements favor zinc.

Sacrificial anodes used in ballast tanks and ship hull areas may be exposed to alternating wet-dry conditions. In this environment, corrosion products on the anode surface can dehydrate and form hard oxide layers. As wet-dry cycling continues, these corrosion products may accumulate and form a dense surface layer, reducing the contact area between the anode and seawater and affecting anode performance. This may be reflected by a positive shift in anode potential, reduced activity, and lower current efficiency.

Advance Technology has developed zinc alloy anodes suitable for wet-dry cycling conditions encountered in marine applications. The figures show the closed-circuit potential and capacity performance of different zinc alloy anodes under wet-dry cycling conditions. After 10 wet-dry cycles, the Advance Technology zinc alloy anode achieved a closed-circuit potential of -1.00 V and a capacity of 780 Ah/kg, representing an approximately 10% improvement in electrochemical performance compared with other zinc alloy anodes.



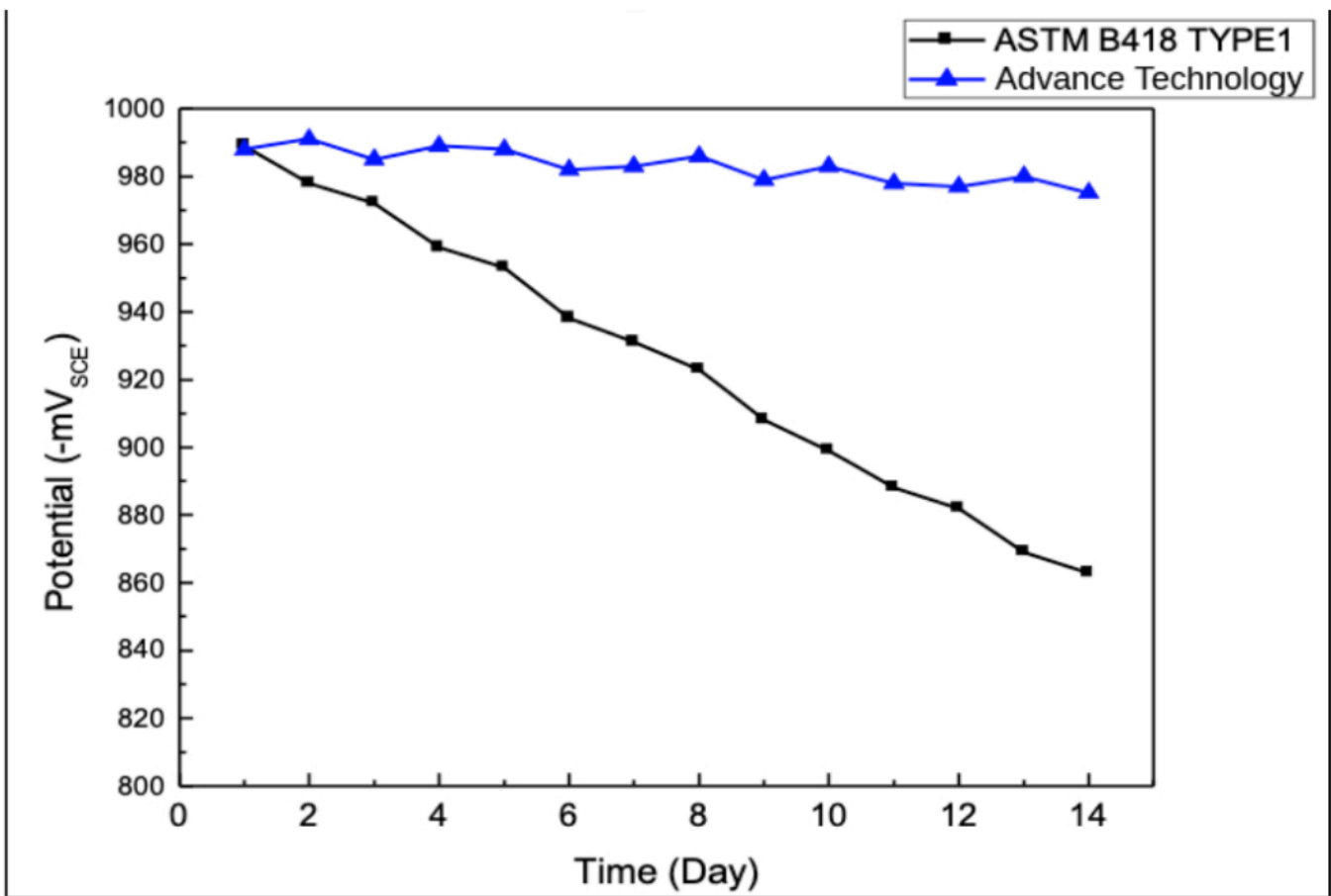
Closed-Circuit Potential vs. Wet-Dry Cycle Number for Zinc Alloy Anodes



Electrochemical Capacity of Zinc Alloy Anodes after Wet-Dry Cycling

High Temperature Zinc Alloy Anode

In petroleum and chemical processing facilities, many oil and gas systems operate under elevated temperature and pressure. For structural steels used in these demanding conditions, hydrogen embrittlement caused by overprotection during cathodic protection is a critical concern. In some services, the oily water inside the equipment may also have relatively high resistivity ($> 2 \Omega \cdot m$), which can limit the suitability of aluminum alloy sacrificial anodes. In such applications, zinc alloy sacrificial anodes may provide a suitable low-driving-potential option.



Closed-Circuit Potential vs. Time for Zinc Alloy Anodes at High Temperature

Conventional zinc alloy anodes are generally used in environments below 50 °C. At temperatures above 50 °C, conventional zinc alloy anodes may experience intergranular corrosion, causing the closed-circuit potential to shift in the positive direction and increasing the risk of polarity reversal between the anode and cathode.

Advance Technology has developed specially formulated zinc alloy anodes for high-temperature service. The figure shows the working potential of different zinc alloy anodes in oily water at 70 °C over time. Under the specified test conditions, Advance Technology zinc alloy anodes achieved a closed-circuit potential of -0.97 V and a capacity of 770 Ah/kg at elevated temperature.

PRODUCT PARAMETERS

Chemical Composition

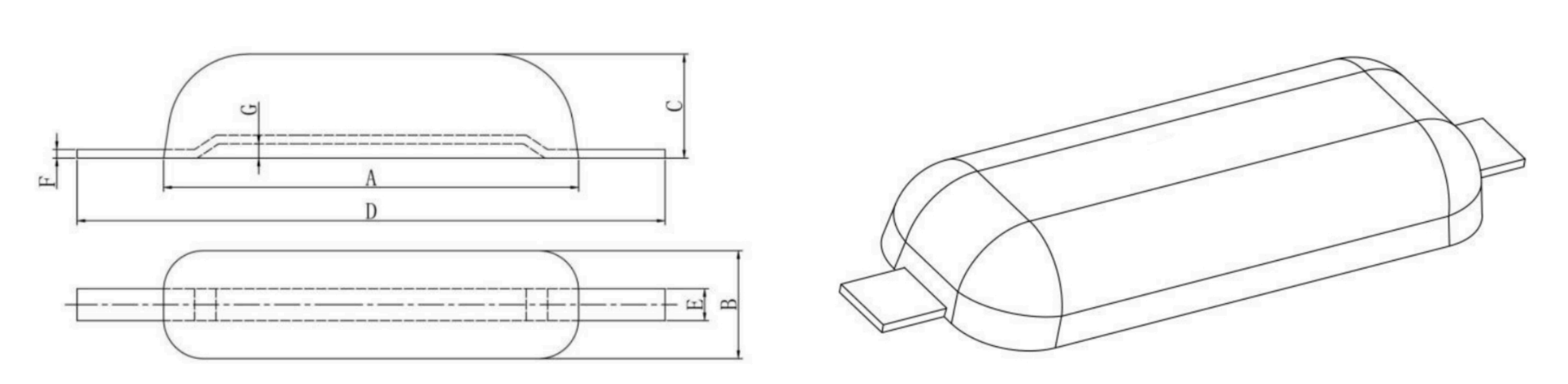
Model	ASTM B418 Type I	ASTM B418 Type II
Al %	0.10 - 0.50	≤0.0050
Cd %	0.025 - 0.070	≤0.0030
Mg %	—	—
Fe %	≤0.0050	≤0.0014
Pb %	≤0.0060	≤0.0030
Cu %	≤0.0050	≤0.0020
Others%	≤0.10	—
Zn	Remainder	Remainder

Electrochemical Properties

Model	ASTM B418 Type I	ASTM B418 Type II
Open-circuit Potential (-V, SCE)	≥1.05	≥1.10
Closed-circuit Potential (-V, SCE)	≥1.00	≥1.05
Current Capacity (A.h/kg)	≥780	≥740
Current Efficiency (%)	≥95	≥90

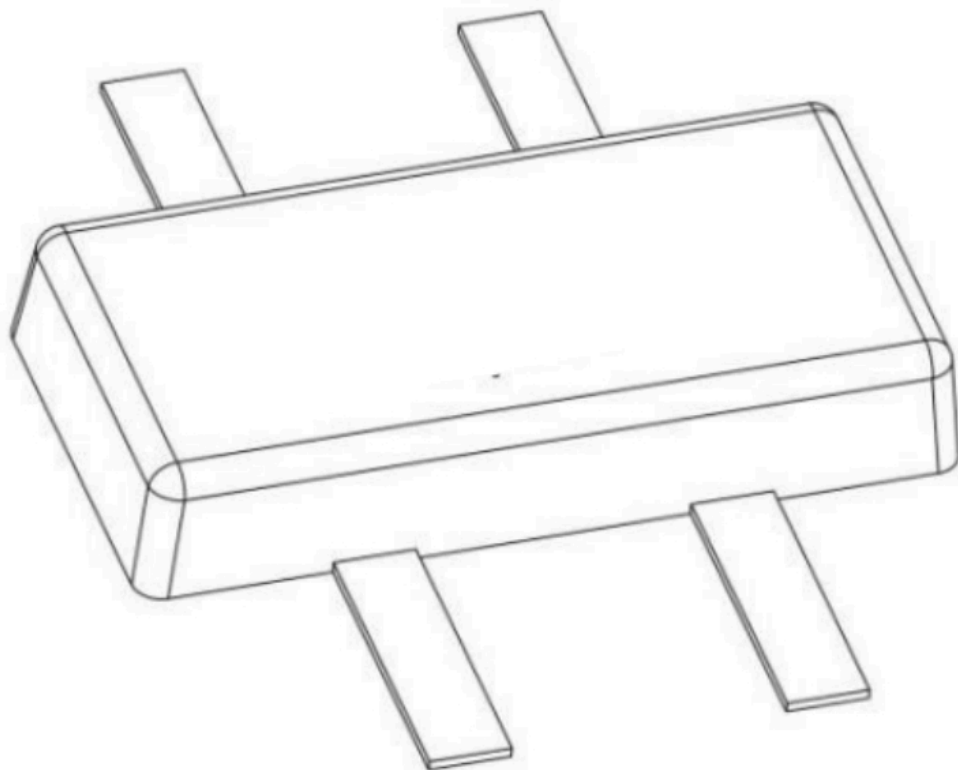
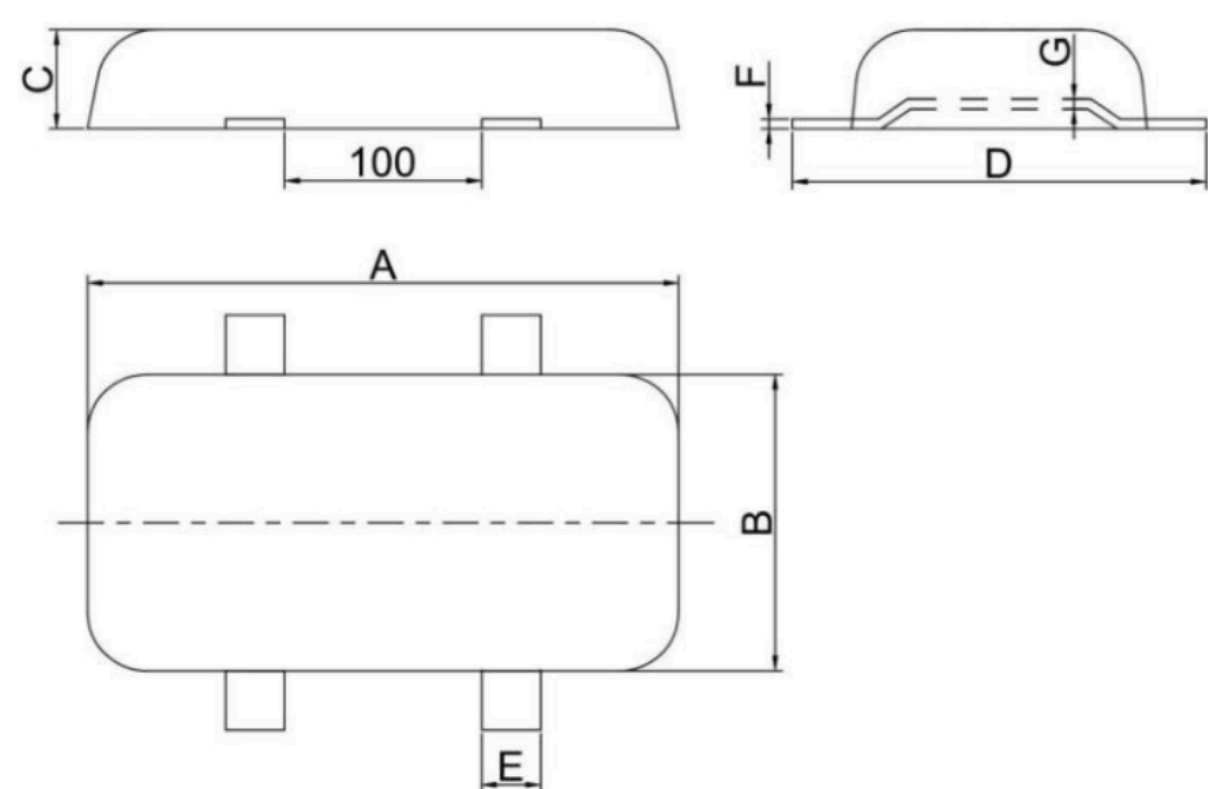
MODELS AND SPECIFICATIONS

Hull Anode (Single Core)



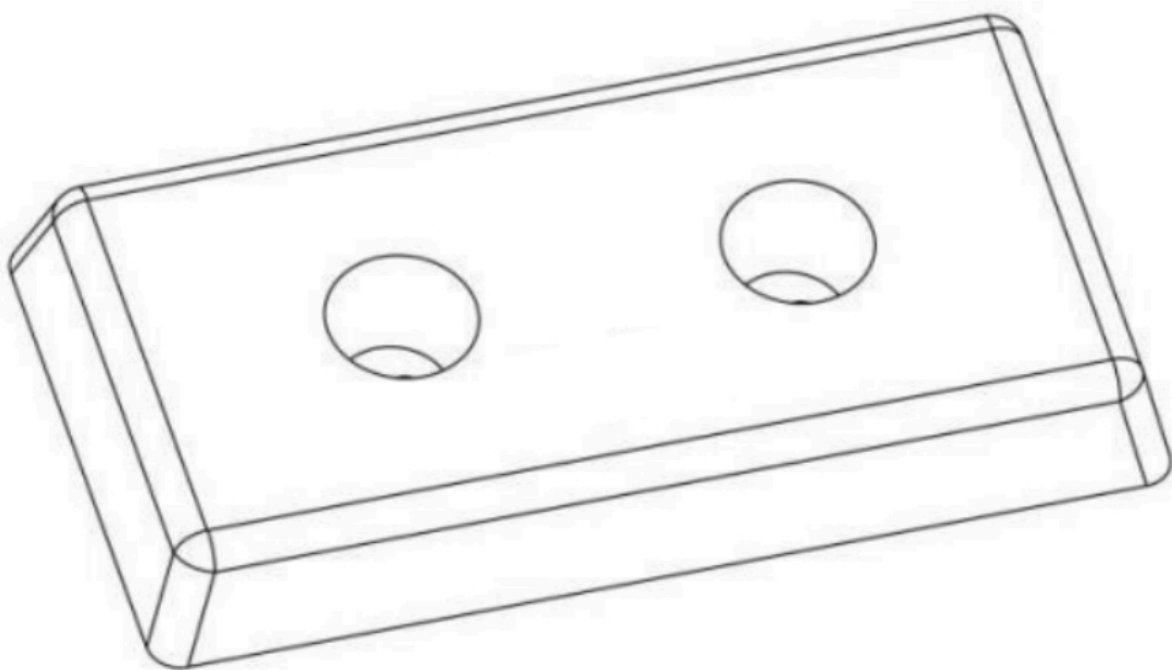
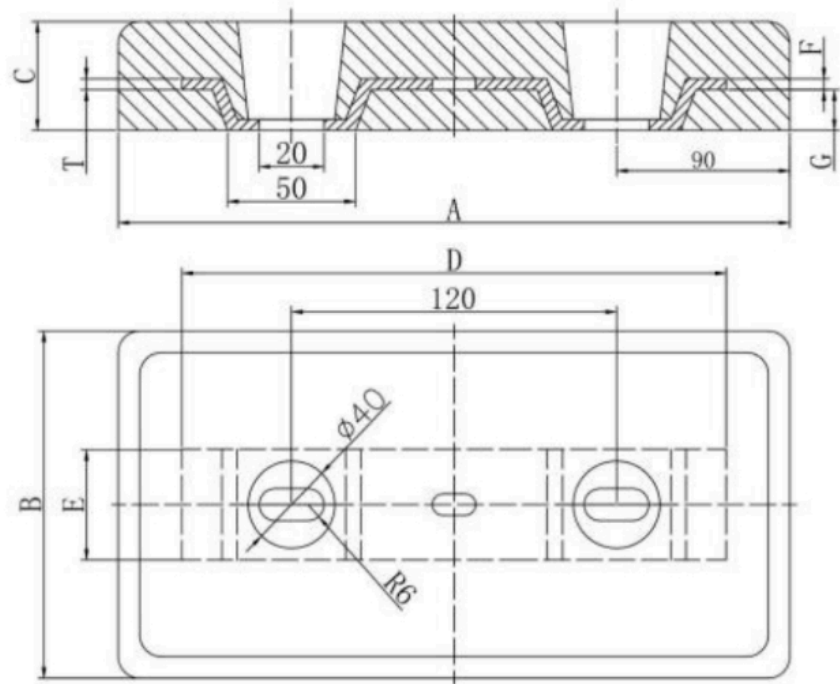
Model	Standard Size (mm)	Core Size (mm)				Net Weight (kg)	Gross Weight (kg)
	A×B×C	D	E	F	G		
AT-ZN-H-1	800×140×60	900	45	6	10	38.2	40
AT-ZN-H-2	800×140×50	900	45	6	8	32.7	34.5
AT-ZN-H-3	800×140×40	900	45	6	6	26.7	28.5
AT-ZN-H-4	600×120×50	700	40	6	8	20.4	21.6
AT-ZN-H-5	400×120×50	470	35	5	8	13.5	14.1
AT-ZN-H-6	500×100×40	580	40	5	6	11.4	12.2
AT-ZN-H-7	400×100×40	460	30	5	6	9.1	9.6
AT-ZN-H-8	300×100×40	360	30	4	6	6.8	7.1
AT-ZN-H-9	250×100×40	310	30	4	6	5.6	5.8
AT-ZN-H-10	180×70×40	230	25	4	6	2.5	2.7

Hull Anode (Double Core)



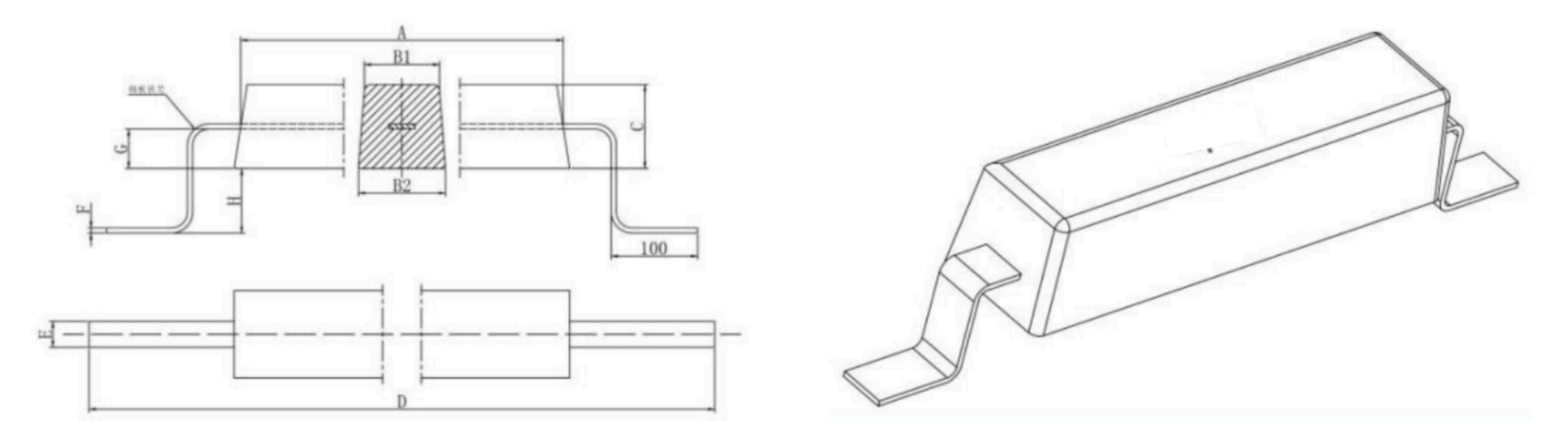
Model	Standard Size (mm)	Core Size (mm)				Net Weight (kg)	Gross Weight (kg)
	A×B×C	D	E	F	G		
AT-ZN-H-11	300×150×50	360	30	4	6	14.8	15.4
AT-ZN-H-12	300×150×40	360	30	4	6	11.8	12.4

Hull Anode (Bolted Type)



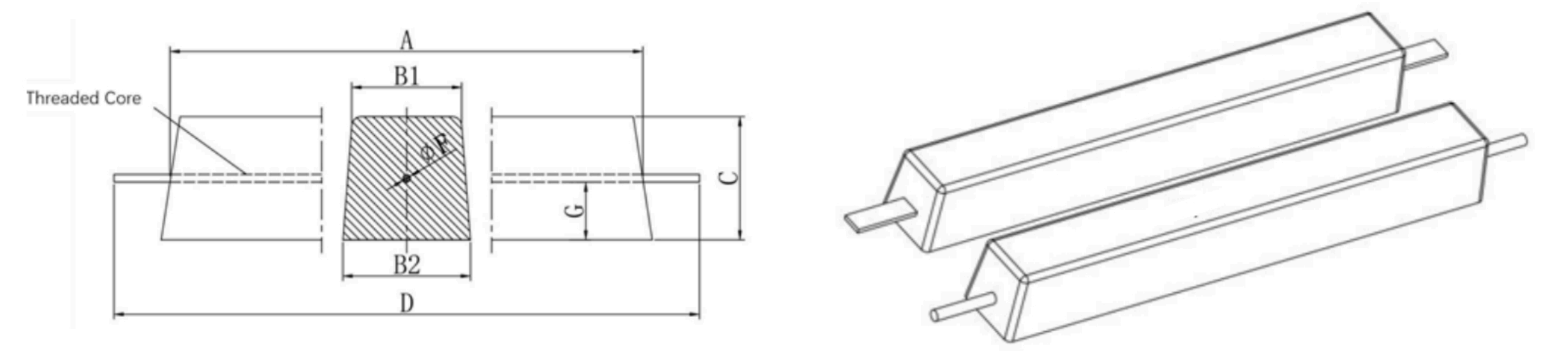
Model	Standard Size (mm)	Core Size (mm)				Net Weight (kg)	Gross Weight (kg)
	A×B×C	D	E	F	G		
AT-ZN-H-13	300×150×50	250	50	3	10	14.8	15
AT-ZN-H-14	300×150×40	250	50	3	10	11.8	12

Ballast Tank Anode



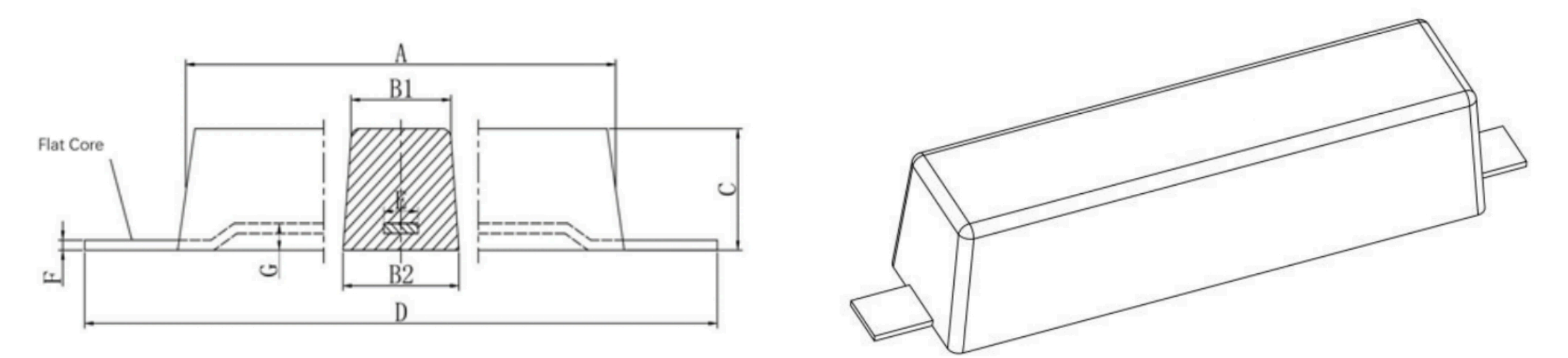
Model	Standard Size (mm)	Core Size (mm)					Net Weight (kg)	Gross Weight (kg)
	A× (B1+B2) ×C	D	E	F	G	H		
AT-ZN-T-1	500× (115+135) ×130	800	50	6	40	60	56.9	59.3
AT-ZN-T-2	1500× (65+75) ×70	1800	—	φ16	20	40	50	53.1
AT-ZN-T-3	500× (110+130) ×120	800	50	6	40	60	50	52.4
AT-ZN-T-4	1000× (58.5+78.5) ×68	1300	—	φ16	20	40	31.6	34
AT-ZN-T-5	800× (56+74) ×65	1100	—	φ16	20	40	23	25
AT-ZN-T-6	1150× (48+54) ×51	1450	—	φ12	15	35	20.5	21.9
AT-ZN-T-7	250× (80+100) ×85	310	30	4	8	0	13.4	13.7
AT-ZN-T-8	200× (70+90) ×70	260	30	3	8	0	7.8	8

Marine Structure Anode



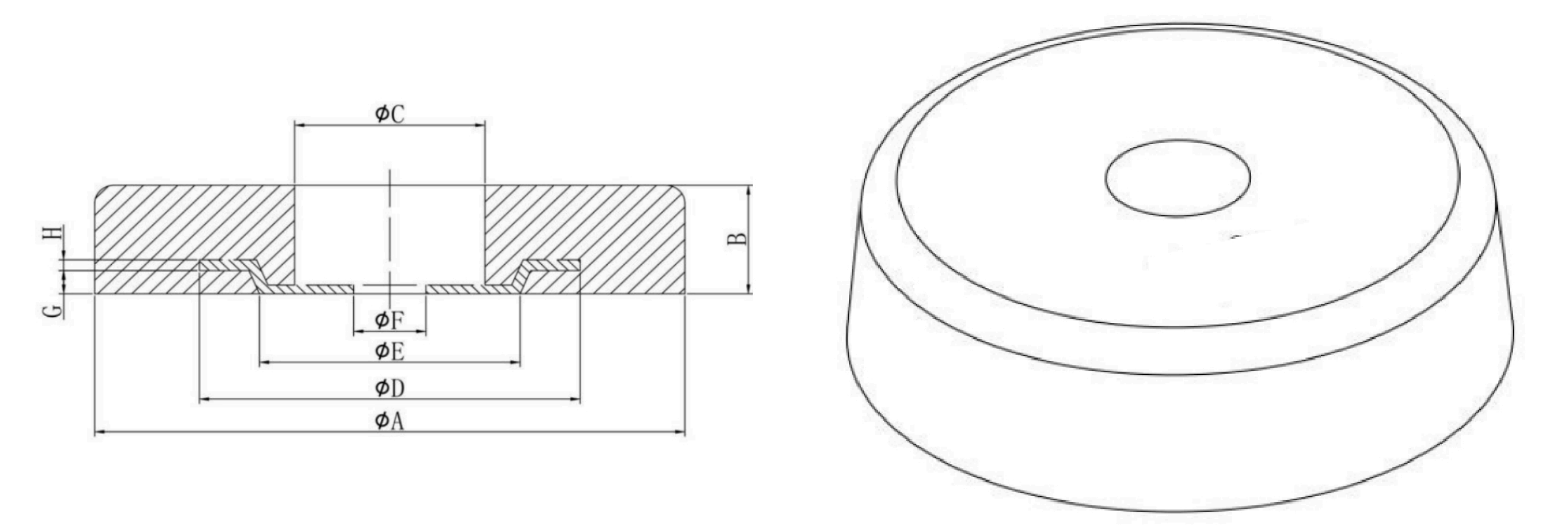
Model	Standard Size (mm)	Threaded Core Size (mm)			Flat Core Size (mm)				Net Weight (kg)	Gross Weight (kg)
	A × (B1+B2) × C	D	F	G	D	E	F	G		
AT-ZN-I-1	1000 × (115+135) × 130	1250	18	45	1250	40	8	45	114.1	116.5
AT-ZN-I-2	750 × (115+135) × 130	1000	16	45	1000	40	6	45	86	87.5
AT-ZN-I-3	500 × (115+135) × 130	750	16	45	750	40	8	45	56.9	58
AT-ZN-I-4	500 × (105+135) × 100	750	16	35	750	40	6	35	41.9	43

Cooling System Anode (Slender Type)



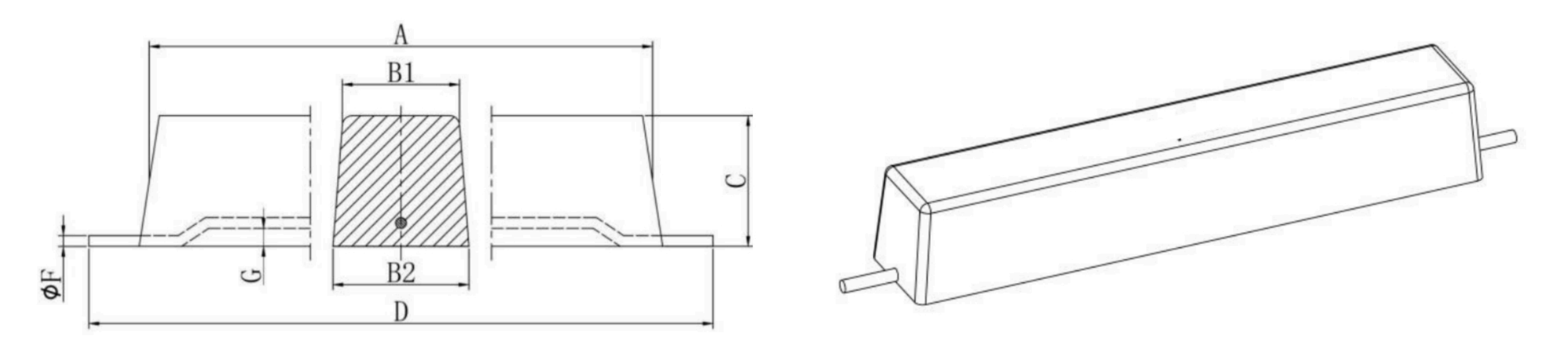
Model	Standard Size (mm)	Core Size (mm)				Net Weight (kg)	Gross Weight (kg)
	A× (B1+B2) ×C	D	E	F	G		
AT-ZN-E-1	500× (115+135) ×130	620	50	6	10	56.9	58.3
AT-ZN-E-2	1000× (80+100) ×80	1200	30	6	8	50	51.7
AT-ZN-E-3	500× (105+135) ×100	620	40	6	10	42	43.2
AT-ZN-E-4	500× (80+100) ×80	620	30	6	8	24.8	25.6
AT-ZN-E-5	400× (110+120) ×50	500	35	4	6	15.8	16.3
AT-ZN-E-6	300× (140+160) ×40	360	60	4	6	12.3	13
AT-ZN-E-7	200× (90+110) ×40	250	30	3	6	5.5	5.7

Cooling System Anode (Disc Type)



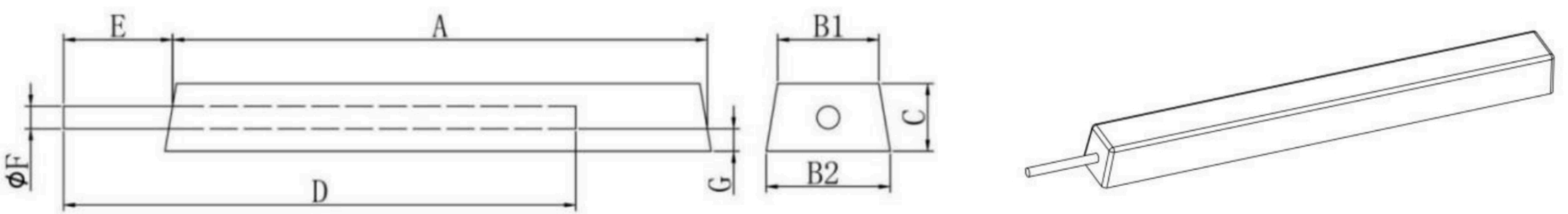
Model	Standard Size (mm)	Core Size (mm)						Net Weight (kg)	Gross Weight (kg)
	A×B	C	D	E	F	H	G		
AT-ZN-E-8	300×60	40	80	50	12	6	6	28.4	28.6
AT-ZN-E-9	360×40	50	100	70	14	5	6	27.3	27.6
AT-ZN-E-10	300×40	40	80	50	12	5	6	18.8	19
AT-ZN-E-11	200×50	35	75	45	10	5	4	10	10.2
AT-ZN-E-12	180×50	35	75	45	10	5	4	8	8.1
AT-ZN-E-13	120×100	30	75	45	10	8	4	6.5	6.7

Tank Internal Anode



Model	Standard Size (mm)	Core Size (mm)			Net Weight (kg)	Gross Weight (kg)
	A× (B1+B2) ×C	D	F	G		
AT-ZN-C-1	750× (115+135) ×130	900	16	10	85.6	86.9
AT-ZN-C-2	500× (115+135) ×130	650	16	10	57	58
AT-ZN-C-3	500× (105+135) ×100	650	16	10	41.9	42.9
AT-ZN-C-4	300× (105+135) ×100	400	12	10	25.3	25.6

Buried Pipeline Anode



Model	Standard Size (mm)	Core Size (mm)				Net Weight (kg)	Gross Weight (kg)
	A× (B1+B2) ×C	D	E	F	G		
AT-ZN-P-1	1000× (78+88) ×85	700	100	16	30	49.4	50.4
AT-ZN-P-2	1000× (65+75) ×65	700	100	16	25	31.5	32.5
AT-ZN-P-3	800× (60+80) ×65	600	100	12	25	25.5	26
AT-ZN-P-4	800× (55+64) ×60	500	100	12	20	20	20.4
AT-ZN-P-5	650× (58+64) ×60	400	100	12	20	16.6	16.9
AT-ZN-P-6	550× (58+64) ×60	400	100	12	20	14	14.3
AT-ZN-P-7	600× (52+56) ×54	460	100	12	15	12.1	12.5
AT-ZN-P-8	600× (40+48) ×45	360	100	12	15	8.2	8.5

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