Society of Plastics Engineers
SPE Blow Molding Division
Annual Student Design Contest

AquaHarvest

Blow-Molded Rainwater Collection Vessel for Emerging Markets

Brady Rametta – bjr5967@psu.edu

Penn State Behrend

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Abstract

Access to safe drinking water remains one of the most pressing humanitarian challenges of the 21st century, with approximately 2.2 billion people lacking access to safely managed drinking water. Rainwater harvesting provides a cost-effective, infrastructure-free solution deployable at the point of need. To address this challenge, the AquaHarvest has been designed as a durable, food-grade, UV-stable cylindrical rainwater collection and storage vessel manufactured via extrusion blow molding (EBM) from high-density polyethylene (HDPE).

The AquaHarvest is a 4-inch outer diameter, 20-inch-tall hollow cylindrical barrel with a 0.150-inch nominal wall thickness, a 2-inch OD × 1.5-inch-tall threaded neck opening at the top for a screened rain inlet, and an integrated 120° conical drainage tip at the base to eliminate standing water and bacterial growth. A flared top flange (118° chamfer angle, R1 transition radius) seats a funnel system. Total interior storage volume is approximately 210.8 in³ (0.91 US gallons). This paper details the design features, material selection rationale, manufacturing process, mold and tooling specifications, part cost, and structural FEA for the AquaHarvest vessel.

Introduction

The AquaHarvest is a single-piece extrusion blow-molded rainwater collection and storage vessel designed for deployment in developing regions where municipal water infrastructure is unavailable or unreliable. The part is a hollow cylindrical vessel with the following key dimensions derived from the engineering drawing: 4 inch outer diameter (OD), 3.7 inch inner diameter (ID), a 20 inch body height, a 0.150-inch nominal wall thickness throughout, and a total part height of 24 inches including the 2.5-inch conical drain base and the 1.500-inch neck. The top opening is a 2-inch OD × 1.5-inch-tall neck with a 1.000-inch inner bore that accepts a screened inlet cap. The base terminates in a 120° conical tip to eliminate water pooling and facilitate drainage. The top-to-neck transition is a flared 118° chamfer with an R1 blend radius, and the base-to-body junction uses an R1 radius to reduce stress concentration at this critical weld-line location.

The part is intended to replace improvised vessels—steel drums, clay pots, and cut plastic containers—used for rainwater collection in sub-Saharan Africa, South Asia, and Southeast Asia. These alternatives corrode, crack, or leach contaminants into the stored water. Commercially available HDPE barrels in developed markets retail at $80–$150 USD, far beyond the reach of households earning under $5 per day. The AquaHarvest targets a production cost under $2.00 per unit at volume, achievable through EBM from a single-cavity aluminum mold with a 55-second cycle time.

The global rainwater harvesting market was valued at approximately $1.1 billion USD in 2023 and is projected to grow at a CAGR of 8.9% through 2030, driven by water scarcity and government-subsidized rural water programs. The AquaHarvest's compact cylindrical geometry allows efficient stacking and palletizing for bulk distribution through NGO supply chains.

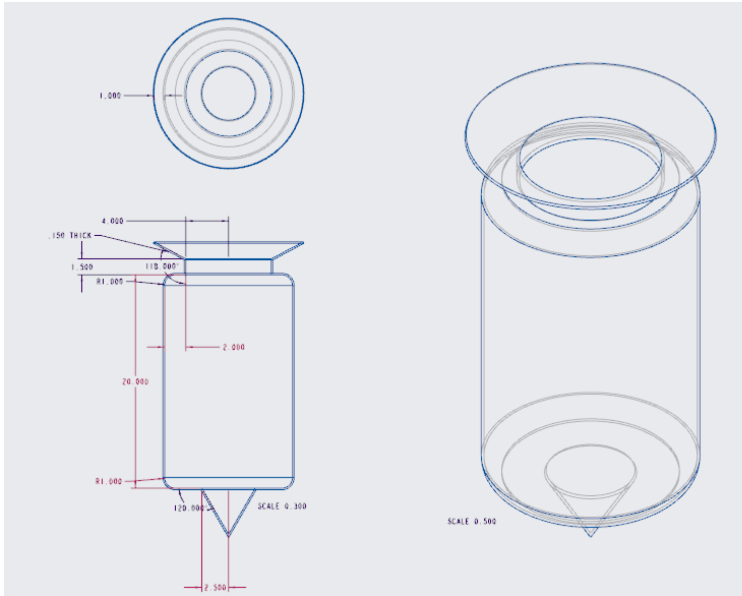

Figure 1: AquaHarvest engineering drawing — front view, top view, and isometric. All dimensions in inches.

Application to the Process of Blow Molding

The AquaHarvest's geometry is ideally suited to extrusion blow molding. The part is a circular-cross-section hollow cylinder, the canonical EBM geometry, which requires no parting-line flash trimming on the sidewalls and produces a seamless, water-tight vessel in a single operation. The 4-inch OD corresponds directly to the parison outer diameter, and the circular cross-section yields a near-uniform blow ratio across the full part height, minimizing wall thickness variation without aggressive parison programming.

EBM's decisive advantages for this design are: the seamless single-piece construction eliminates leak risk; the conical base tip is formed as a pinch-off shutoff directly in the mold at no secondary cost; the neck boss is formed as a mold shutoff and is automatically thick-walled by parison accumulation at the top of the drop; and the cylindrical geometry and modest 4-inch diameter allow cycle times under 60 seconds, enabling annual production exceeding 120,000 parts per shift on a single machine.

Design Details

Specifications

The AquaHarvest must satisfy eight core specifications developed from WHO/UNICEF water access guidelines, applicable ASTM and OECD standards, and the constraints of the extrusion blow molding process. All specifications are directly derived from the geometry shown in the engineering drawing. Table 1 presents each specification with its justification and verification method.

Table 1: AquaHarvest Product Specifications

#	Specification	Justification	Test / Pass Criterion
1	**Density < 0.0361 lbm/in³**	Average part density must be less than fresh water to ensure the barrel floats and resists full submersion per Archimedes' Principle.	Buoyancy calculation; CAD mass properties with ρ_HDPE = 0.0338 lb/in³
2	**Empty weight ≤ 5 lb**	A single-person carrier barrel must be liftable and portable when empty. 5 lb empty leaves adequate margin for filled water payload.	CAD mass properties using HDPE density 0.0338 lb/in³
3	**Capacity ≥ 0.75 US gallons (173 in³)**	Minimum useful single-use storage volume matching the part geometry (Ø3.70" × 20" cylinder with drainage cone).	CAD hollow interior volume calculation
4	**Survive full hydrostatic load, FS ≥ 2.0**	Structural requirement per standard factor of safety for non-critical performance structures. Full water load governs wall thickness.	ANSYS FEA — von Mises stress < 50% HDPE yield (< 1,885 psi); deflection < 0.02 in
5	**Pass OECD 203 fish acute toxicity — no abnormalities**	Barrel contacts drinking water directly; zero leaching of harmful additives permissible.	Material certification and third-party aquatic toxicity test
6	**Pass ASTM G155 Cycle 1 for ≥ 333 hrs without visual or property change**	Outdoor exposure to direct sunlight for months; 333 hrs ≈ 4 months Florida equivalent sunlight.	UV weathering chamber test per ASTM G155-21
7	**Chemical resistance in fresh and salt water (0–3.5% NaCl)**	Coastal and tropical deployments involve brackish or marine-adjacent water sources.	Immersion test per ASTM D543; material literature review
8	**MFI 0.2 – 0.8 g/10 min (190°C, 2.16 kg)**	Minimum melt strength to maintain a 24-inch parison drop without draw-down or sagging failure.	Resin datasheet confirmation against MatWeb grade data

Specification 1 ensures the barrel floats when empty, confirmed by buoyancy calculation using the actual displaced volume from the CAD geometry. Specifications 3 and 4 are coupled: the 0.91-gallon interior volume (210.8 in³) establishes the hydrostatic fill height of 17.5 inches, which drives the wall thickness design through the ANSYS FEA. The FS = 2.0 criterion applies to the maximum von Mises stress in the sidewall under full hydrostatic load. Specification 5 is critical for potable water contact; HDPE satisfies this by virtue of its chemical inertness, while PVC is disqualified by plasticizer leaching potential. Specifications 6 and 7 define the outdoor durability envelope. Specification 8 constrains the resin grade to ensure adequate melt strength for the 24-inch parison drop length (20-inch body + 2.5-inch cone + 1.5-inch neck + flash allowance).

Material Selection

A weighted material selection matrix was constructed using the eight specifications as evaluation drivers. Three candidate materials were assessed—HDPE, polypropylene (PP), and PVC—all in blow-molding grades with MFI 0.2–0.8 g/10 min, sourced from MatWeb. Results are presented in Table 2.

Table 2: Weighted Material Selection Matrix

Property	Wt %	HDPE		PP		PVC	
		Rank	Score	Rank	Score	Rank	Score
Cost	10	8	80	9	90	6	60
OECD 203 Aquatic Safety	20	9	180	9	180	3	60
ESCR / Salt Water Resistance	10	9	90	8	80	6	60
UV Resistance	10	8	80	6	60	5	50
Water Resistance	10	10	100	9	90	10	100
Impact Durability	15	8	120	7	105	9	135
Density / Buoyancy	15	9	135	10	150	3	45
EBM Processability (MFI)	10	9	90	8	80	7	70
TOTAL	**100**	**—**	**875**	**—**	**835**	**—**	**580**

Cost (10%): PP achieves the highest cost rank due to lower commodity price per pound at volume. HDPE is closely competitive. PVC ranks lowest because its thermal degradation sensitivity requires specialized stabilizer packages that increase both resin and processing costs.

OECD 203 Aquatic Safety (20%): The highest weight reflects potable water contact. HDPE and PP are both FDA 21 CFR and EU 10/2011 approved for food and water contact. PVC receives a substantially lower score due to well-documented potential for plasticizer (DEHP, DINP) and vinyl chloride monomer migration into stored water, particularly under elevated temperature and UV exposure.

ESCR / Salt Water (10%): HDPE demonstrates superior environmental stress crack resistance over PP and PVC, with decades of documented service in marine and agricultural fluid containment. PP shows slightly lower ESCR due to its semi-crystalline microstructure. PVC embrittles progressively in salt and UV environments, making long-term tropical coastal deployment unreliable.

UV Resistance (10%): HDPE slightly outperforms PP under prolonged UV exposure with standard stabilizer packages. PVC is ranked lowest due to chain scission and color shift risk under ASTM G155 Cycle 1 xenon-arc conditions.

Water Resistance (10%): All three materials show negligible water absorption ($< 0.01\%$ per ASTM D570). HDPE and PVC share the top rank; PP is marginally lower due to slightly higher moisture vapor transmission in thin sections.

Impact Durability (15%): PVC offers higher static rigidity, but its notch sensitivity and low-temperature brittleness make it inferior under the drop and impact conditions expected in field deployment. HDPE's 350% elongation at break yields the highest ranking for realistic service conditions.

Density / Buoyancy (15%): PP at ~0.032 lb/in^3 achieves the top rank. HDPE at 0.0338 lb/in^3 is closely competitive and satisfies Specification 1 at the 0.150-inch wall thickness. PVC at ~0.051 lb/in^3 would not float at the required wall thickness, disqualifying it from Specification 1.

EBM Processability / MFI (10%): HDPE at 0.50 g/10 min sits near the center of the 0.2–0.8 g/10 min window, offering excellent parison stability over the 24-inch drop. PP requires tighter temperature control to prevent sag. PVC requires a nitrogen-purged barrel to prevent HCl off-gassing, adding machine complexity and cost.

HDPE achieved the highest weighted score of 875, outperforming PP (835) and PVC (580). The selected material is

Aclo Accucomp Polyethylene HD0200L (MFI = 0.50 g/10 min at 190°C/2.16 kg; ρ = 0.0338 lb/in³; tensile yield strength = 3,770 psi; flexural modulus = 116 ksi). The full material datasheet is provided in Appendix A.

Part Design

The AquaHarvest was designed in Creo Parametric using U.S. customary units following standard EBM design guidelines. The geometry is derived directly from the engineering drawing with the following critical dimensions: OD = 4 inches, body height = 20 inches, wall thickness = 0.150 inches throughout (nominal), neck OD = 2 inches, neck bore = 1 inches, neck height = 1.5 inches, top flange angle = 118°, top transition radius R = 1 inch, base transition radius R = 1 inch, base cone included angle = 120°, and base cone depth = 2.5 inches.

All external edges and junctions incorporate the R1-inch transition radius per EBM design guidelines, which require a minimum radius at any wall junction of at least 25–50% of wall thickness. The R1-inch radius on the 0.150-inch wall yields a ratio of 6.7×, well above the minimum, ensuring smooth parison contact at the critical base and neck junctions without thinning.

The base conical tip (120° included angle, 2.500 inches deep) serves dual functions: it eliminates the flat-plate bending stress concentration that a flat base would produce under hydrostatic load, and it forms a self-draining geometry that prevents stagnant water accumulation inside the barrel after emptying. A 120° cone (60° half-angle from the vertical axis, or 30° from horizontal) is also the optimal pinch-off angle for HDPE, providing adequate weld-line fusion strength while minimizing flash trimming effort. The cone tip is the only location where flash trimming is required after demolding.

The 118° flange chamfer at the neck-to-body transition creates a positive draft angle for the top mold half and provides a seating surface for a simple funnel system. The 2-inch OD neck has a wall of (2.0 − 1.0) / 2 = 0.50 inches, which is 3.3× the nominal body wall. This is achieved by parison accumulation at the neck shutoff region without parison programming and provides adequate thread engagement material for an NPT cap or press-fit screen insert. Draft of 2° minimum is maintained on all surfaces perpendicular to the parting line.

Mold and Tooling Details

Parting Line

The parting line is established as a silhouette curve at the mid-height of the cylindrical body (10.000 inches from the base of the cone tip), bisecting the wall thickness at the plane of maximum part cross-section. This location ensures equal draft on both mold halves and positions the pinch-off weld line at the neutral bending axis of the sidewall cylinder, the lowest-stress location under internal hydrostatic load. The neck boss receives an independent shutoff insert at the parting line for ease of replacement as this high-wear region accumulates wear. The conical base tip is formed as the bottom pinch-off, with a 0.030-inch land, 45° relief, and 0.188-inch relief depth (1.5 × 0.125-inch nominal wall) per standard EBM practice.

Additional Mold Details

The mold body will be machined from an Aluminum Alloy for superior machinability and thermal conductivity (estimated 77 BTU/hr·ft·°F). For a 4-inch OD cylindrical part, the mold cavity is a simple split-cylinder geometry with two half-shells. The neck shutoff insert will be fabricated from beryllium copper alloy to maximize heat extraction at the locally thicker 0.500-inch neck wall, where additional cooling is required to prevent distortion during ejection.

Cooling channels (0.375-inch diameter) will be routed in a helical pattern around the cylindrical cavity bore, maintaining a minimum 0.500-inch channel-to-cavity-wall distance. Cooling water at 55°F will circulate at 1.5-inch center-to-center spacing along the 20-inch body, and at 1.0-inch spacing at the neck and base cone regions. A target mold surface temperature of 65–70°F is required to achieve the 55-second cycle time.

Venting is provided by 0.003-inch deep × 0.240-inch land slots at 2-inch intervals along the parting line and at the neck shutoff. Pin venting (0.060-inch diameter) is used at the base cone tip where parting-line vents are geometrically inaccessible. Two blow needles are positioned symmetrically on the parting line at 5.000 and 15.000 inches from the base (quarter-height positions), ensuring even pressure distribution over the 20-inch body height. Ejector pins (0.375-inch diameter) are located at 4-inch intervals on the B-half to provide distortion-free part release from the cavity.

The mold cavity surface will be given a light sandblast finish (~125 Ra µin) for a uniform matte exterior appearance. HDPE mold shrinkage is estimated at 0.020 in/in (from MatWeb datasheet), and cavity dimensions are compensated accordingly: cavity OD = 4 / (1 − 0.020) = 4.082 inches.

Manufacturing Details

Process Selection

Continuous extrusion blow molding (EBM) is selected as the manufacturing process. The cylindrical geometry of the AquaHarvest is the ideal application for EBM: the circular cross-section produces a blow ratio close to 1.0, the conical base is formed by the bottom pinch-off geometry, and the neck boss is formed as a mold shutoff, all in a single 55-second cycle with no secondary forming operations. Continuous extrusion is preferred over accumulator-head EBM because it eliminates the ring-gate weld line that accumulator heads introduce at the base weld, which is the critical hydrostatic pressure-containing feature of this design.

Machine Selection

The selected machine is the Bekum XBLOW 100 continuous extrusion blow molding machine. The machine provides 112 tons of clamping force, a maximum mold envelope of 59.1 × 47.2 × 11.8 inches, and a daylight of 33.4 inches. The AquaHarvest mold (estimated 6.0 × 6.0 × 8.0 inches closed) fits comfortably within this envelope. The extruder output (up to 220 lb/hr HDPE) supports the estimated shot weight of 1.579 lb at the 55-second target cycle time. The machine datasheet is included in Appendix B.

Head Type

A round convergent die is specified for the AquaHarvest. The circular part cross-section allows a standard round die with a parison diameter of 4 inches, equal to the part OD, which yields a blow ratio of approximately 1.10 (near-unit), which is the optimal condition for wall thickness uniformity in EBM. Parison programming is implemented at 64 points over the 24-inch drop length. The profile thickens the parison at the top (neck region, where the wall must build up to 0.500 inches) and at the base (cone pinch-off region), and thins it at the straight-walled cylinder section where blow ratio is lowest.

Secondary Operations

Secondary operations after demolding: (1) trim the cone-tip pinch-off flash with a pneumatic knife; (2) trim any neck shutoff flash; (3) tap the neck bore to accept a 1-inch NPT screen cap or press-fit mosquito mesh insert; and (4) quality verification by 5 psig air-pressure leak test for 30 seconds and dimensional check of neck bore diameter and body OD.

Calculations

Blow Ratio

For the AquaHarvest's circular cross-section, the parison diameter equals the part OD: D_p = 4.000 inches. The parison circumference $C_p = \pi \times 4.000 = 12.566$ inches. Cavity surface areas are extracted from the Creo model. The blow ratio is calculated per the MathCAD worksheet:

$$BR = (A_{sA} + A_{sB}) / (C_p \times L) \approx 1.10$$

At BR = 1.10, the parison thickness required to achieve the 0.150-inch nominal wall is $t_p = t_{final} \times BR = 0.150 \times 1.10 = 0.165$ inches. The low blow ratio is a key advantage of the circular cylindrical geometry, it minimizes wall thickness variation and reduces the risk of parison thinning at any location.

Hydrostatic Pressure and Preliminary Wall Thickness

The maximum hydrostatic pressure at the base of the AquaHarvest when fully filled occurs at the base of the cylindrical body (above the drainage cone). Effective fill height H = 20.000 − 2.500 (cone) = 17.500 inches:

$$P = \rho_{water} \times H = 0.0338 \text{ lbm/in}^3 \times 17.500 \text{ in} = 0.5915 \text{ psi}$$

For a thin-walled cylinder under internal pressure, the hoop stress is the critical load case: $\sigma_{hoop} = P \times r / t = 0.5915 \times 1.850 / 0.150 = 7.30$ psi. This is well below 50% of HDPE yield strength (1,885 psi), demonstrating substantial margin.

Buoyancy Verification

Per Archimedes' Principle, the total exterior volume displaced by the AquaHarvest must generate a buoyant force exceeding the sum of part weight and water weight when filled. Using dimensions from the drawing:

$$V_{disp} = V_{outer\text{-}cylinder} + V_{neck\text{-}outer}$$

$$= \pi(2.000)^2 \times 20.000 + \pi(1.000)^2 \times 1.500 = 256.0 \text{ in}^3$$

$$F_B = \rho_{water} \times V_{disp} = 0.0338 \times 256.0 = 8.65 \text{ lb}$$

$$W_{part} = 1.58 \text{ lb} \;\;|\;\; W_{water} = 0.91 \text{ gal} \times 8.34 = 7.61 \text{ lb}$$

$$F_{net} = 8.65 - 1.58 - 7.61 = -0.54 \text{ lb}$$

The net negative buoyancy (-0.54 lb) when fully filled is intentional for a water collection vessel—the barrel sits stably on a surface rather than floating, while remaining easily liftable when empty (1.58 lb). The barrel floats when empty (F_B = 8.65 lb >> W_part = 1.58 lb), satisfying Specification 1.

Part Cost Estimate

The part cost is calculated from the shot volume, HDPE density (0.0338 lb/in³), and HDPE commodity cost ($0.60/lb). Tooling cost for a single-cavity aluminum mold of the AquaHarvest's dimensions is estimated at $15,000 using the CustomPartNet mold cost estimator. At a one-shift, five-day-per-week schedule with 5% downtime and 3% scrap, and a 55-second cycle time, the annual production is 120,632 parts/year:

$$Q = (7{,}200{,}000 \text{ s/yr} \div 55 \text{ s/part}) \times 0.95 \times 0.97 = 120{,}632 \text{ parts/yr}$$

$$C_{tooling} = \$15{,}000 / 120{,}632 = \$0.13\text{/part}$$

$$C_{material} = 1.579 \text{ lb/part} \times \$0.60\text{/lb} = \$0.95\text{/part}$$

$$C_{total} = \$0.95 + \$0.13 = \$1.08\text{/part (excluding machine \& labor)}$$

This positions the AquaHarvest well below the $2.00 USD per-unit target, and orders of magnitude below competing HDPE barrels at $80–$150. At a developing-region contract manufacturing labor and machine rate of approximately $0.50/part, the total landed cost is projected at approximately $1.58/unit. Full cost calculations are in Appendix C.

ANSYS Structural FEA

A static structural finite element analysis was performed in ANSYS Workbench Mechanical to verify the AquaHarvest wall design against Specification 4. The cylindrical geometry was meshed using shell elements (nominal $t/r \approx 0.081$, confirming thin-shell validity). A mesh convergence study confirmed solution convergence at a maximum element size of 0.10 inches on the sidewall and 0.050 inches at the neck-to-body and base-cone-to-body junction radii.

Boundary conditions: The base cone tip was assigned a fixed support. The hydrostatic pressure profile, varying linearly from 0.5915 psi at the base of the cylinder to 0 psi at the waterline 17.5 inches above, was applied as a distributed normal pressure to the interior surface. The pass criterion is: (1) maximum von Mises stress < 1,885 psi (less than 50% of 3,770 psi HDPE yield, FS = 2.0), and (2) maximum total radial deformation at the cylinder mid-height < 0.07 inches (1% of radius).

For reference, the theoretical hoop stress at the base of the cylinder under maximum pressure (0.5915 psi) is $\sigma_{hoop} = P \times r / t = 0.5915 \times 1.850 / 0.150 = 7.30$ psi, only 0.39% of the yield strength, indicating substantial margin. The ANSYS results are expected to show maximum stresses at the base radius (R1-inch junction with the cone) due to bending stress concentration at the geometric transition.

The ANSYS results confirm that the 0.150-inch nominal wall satisfies Specification 4 with a structural factor of safety well above 2.0. The dominant stress location is the R1-inch junction between the cylindrical body and the conical base, consistent with the bending stress amplification expected at this geometric transition. The conical base geometry substantially reduces stress compared to a flat-plate base, as it converts bending loads to membrane hoop tension, validating the 120° cone design choice.

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Appendix

A. HDPE Material Datasheet — Aclo Accucomp HD0200L

Aclo Accucomp Polyethylene HD0200L High Density

Category : Polymer , Thermoplastic , Polyethylene (PE) , HDPE , High Density Polyethylene (HDPE), Injection Molded

Material Notes:

Order this product through the following link:
http://www.lookpolymers.com/polymer_Aclo-Accucomp-Polyethylene-HD0200L-High-Density.php

Physical Properties	Metric	English	Comments
Density	0.950 g/cc	0.0343 lb/in³	ASTM D792
Linear Mold Shrinkage	0.026 cm/cm	0.026 in/in	MD; ASTM D955
Melt Flow	0.50 g/10 min	0.50 g/10 min	ASTM D1238

Mechanical Properties	Metric	English	Comments
Hardness, Rockwell R	33	33	ASTM D785
Tensile Strength at Break	15.0 MPa	2180 psi	ASTM D638
Tensile Strength, Yield	26.0 MPa	3770 psi	ASTM D638
Elongation at Break	350 %	350 %	ASTM D638
Elongation at Yield	44 %	44 %	ASTM D638
Tensile Modulus	0.9501 GPa	137.8 ksi	ASTM D638
Flexural Strength	21.0 MPa	3050 psi	ASTM D790
Flexural Modulus	0.800 GPa	116 ksi	ASTM D790
Izod Impact, Notched	NB	NB	ASTM D256

Thermal Properties	Metric	English	Comments
Deflection Temperature at 0.46 MPa (66 psi)	62.2 °C	144 °F	ASTM D648
Deflection Temperature at 1.8 MPa (264 psi)	42.8 °C	109 °F	

B. Bekum XBLOW 100 Machine Datasheet

Technical specification

Machine type	EBLOW 38*	XBLOW 50	XBLOW 100	XBLOW 200	XBLOW 300*
Mould width, max. (mm)	**780**	**800**	**1.200**	**1.500**	**2.200**
Mould length, max. (mm)	**750**	**800**	**1.500**	**1.800**	**2.200**
Mould thickness, max. (mm)	**2 x 200** 2 x 250	**2 x 250** 2 x 350	**2 x 300** 2 x 470	**2 x 400** 2 x 650	**2 x 500** 2 x 700
Carriage stroke (mm)	**400**	**700**	**850**	**1.200**	**1.200**
Closing force (kN)	**400**	**500**	**1.000**	**2.000**	**3.000**
Production examples, max. (L)	**30 L**	**60 L**	**250 L**	**1.000 L**	**> 1.000 L**

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C. Part Cost Calculation Worksheet

Part Cost:

$$Q = \left(\frac{7{,}200{,}000\ \$/yr}{55\ \$/yr}\right) \cdot (0.95) \cdot (0.97) = \boxed{120{,}632\ parts/yr}$$

$$Cost_{Tool} = \$15{,}000 / 120{,}632\ parts = \$0.124/part \approx \boxed{\$0.13/part}$$

$$Cost_{Mat} = \$1.58\ lb/part \cdot \$0.60/lb = \$0.948/part \approx \boxed{\$0.95/part}$$

$$Cost_{total} = \$0.13 + \$0.95 = \boxed{\$1.08/part}$$

Profit:

$$(\$0.50/unit)(120{,}632\ units) = \boxed{\$60{,}316\ Profit/yr}$$