



MANUFACTURING

Precision Machines for Threads & Gears

Thank you for your interest in Drake Manufacturing. We are pleased to offer the following preliminary proposal:

DRAKE GS:TE/TI

GRINDING SYSTEM: THREAD EXTERNAL/INTERNAL LINEAR MOTORS

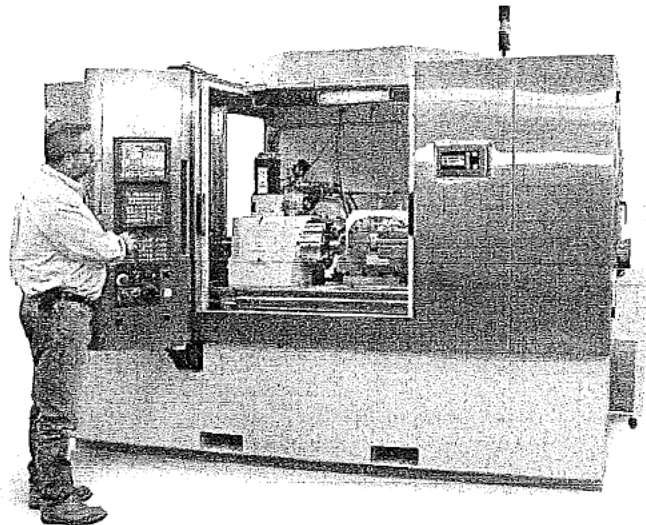


Figure 1: Drake GS:TE/TI 350 Thread Grinder

The Drake GS:TE/TI front dress thread grinder is suitable for grinding Internal or External threads on a part with any lead or helix angle, right or left hand, per the specifications set forth in the table on Page 7. The machine is built on a cast polymer base and is controlled by a state-of-the-art Fanuc CNC. Wheel forms are generated by a servo driven, rotary diamond truing device mounted on the work head. Specifications as well as standard and optional features of the basic machine are set forth below.



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ISO 9001
CERTIFIED

Advantages of Drake CNC thread grinders are:

- **Part Smart™ Process Development**—All Drake machines are fully programmed to run *your* parts before they leave our floor. The Drake Part Smart™ approach assures that your new machine will put *'Parts Out Your Door From Day One.'*

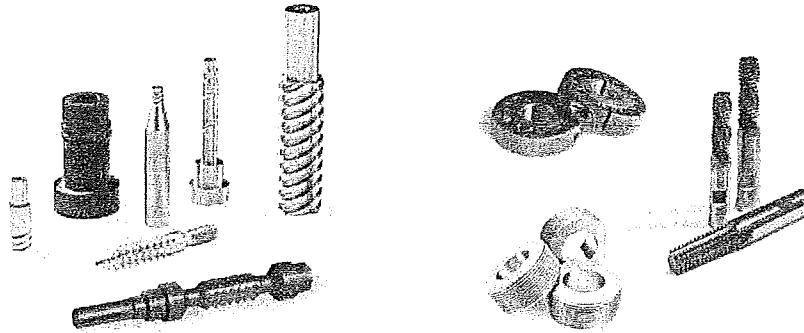


Figure 2: Typical Internal and External Threaded Parts

- **Simple Changeover and Process Control**—Operator controls all process parameters through CNC menu entries. Complete pre-programming of the control specific to your family of parts eliminates in-house programming.
- **Superabrasives Capable**—Machine's structure and kinematics designed for high rigidity, stiffness and precision to run today's and tomorrow's abrasives. Process flexibility is built in to optimize speeds and feeds for grinding and dressing so you can minimize cycle time and process variability whether using aluminum oxide, ceramic, CBN, or diamond abrasives.
- **Consistently Accurate**—Temperature controlled, Fanuc linear motors with high-resolution Heidenhain encoders on positioning axes ensure precision now and after years of multi-shift operation. Linear motors mean no drive train windup, backlash, or lead error due to aging ball screws and couplers.
- **Contour Dress Complex Wheel Forms**—Dress complex topping and non-topping wheel forms including full radius and gothic arch; acme/trapezoidal with crest and root radii or chamfers, as well as 60°, buttress and other thread forms. Optional Smart Form™ software available to correct helical path wheel interference to get the desired form in your high lead angle parts.
- **High Reliability**—CNC diagnostics and simplified ballscrew-free mechanical systems make preventive maintenance easy and keep your Drake producing parts. If something should go wrong, Drake offers unequaled comprehensive phone, remote and on-site service. We set the service standard in our industry—in short, *'You crash, we dash.'*

MACHINE CONSTRUCTION AND STANDARD COMPONENTS

Machine Base. Machine is built on a cast polymer base for vibration damping and thermal stability. Compact, high mass base minimizes required floor space and yet allows high accelerations for minimizing cycle time. Full enclosure guarding keeps even high pressure grinding coolant contained for dry floor operation.

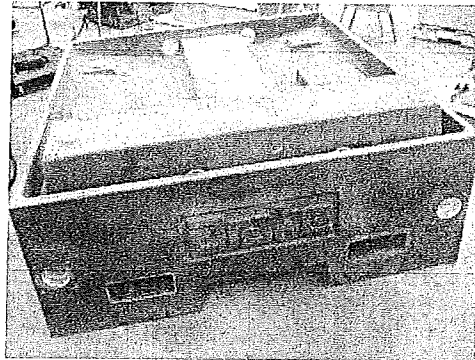


Figure 3: Cast Polymer Base Ready for Assembly

Work (Z-Axis) and Wheel Slides (X-Axis). Cast iron slides are fitted with pre-loaded, permanently lubricated linear roller cars mounted on high-precision rails aligned on a precision sub-plates that are anchored into the machine base. Linear roller ways provide high multidirectional stiffness, accurate steering, and improved vibration damping.

Work Head (C-axis). High precision work head housing is hand scraped, aligned, and fitted to work table. Spindle rotates in preloaded, high-precision angular contact bearings and is driven by an A.C. servomotor with high-resolution encoder and low backlash double-enveloping gear reducer. Spindle has standard A2 spindle nose with thru hole and replaceable Morse taper HSS center. Collet systems, compensating chucks, self-centering chucks and other work head configurations are available.

Tailstock. Worktable equipped with precision tailstock with manual adjustment for product lengths from 25mm to full travel length. Pneumatic powered quill with male, carbide-tipped, Morse taper center provided. Tailstock rated for weights appropriate to the size of the actual machine ordered as set forth on the Specification Table.

Wheel Helix (A-axis). Wheel helix spindle rotates in preloaded precision bearings. Wheel angle established by CNC command to an A.C. servomotor with high resolution encoder driving a low backlash double enveloping gear set.

Feed Systems. High acceleration Fanuc linear motors drive the X- and Z-axes. Use of linear motors virtually eliminates mechanical backlash and positioning errors from wind up and flexing of conventional ballscrews, couplings, and bearing blocks.

Closed-Loop Position Feedback. X- and Z-axes are equipped with Heidenhain, absolute position, linear glass scales for accurate position feedback, no-reference startups, and recoveries after a power outage. Scales provide 0.05 micron resolution for precise size and lead control.

CNC Servo System. Fanuc i-series CNC interfaced with Fanuc A.C. linear motors for X-and Z-axes and rotary servomotor for A- and C-axes. Fanuc offers high count encoder resolution, publishes an average mean time between failures of over 27 years, and provides support through a 24-hour help line in addition to field service engineers.

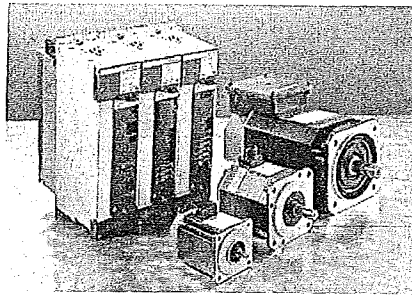


Figure 4: Fanuc CNC, Drives, and Servos

Software. Complete Part Smart™ programming is provided for all menu screens, machine movement macros and the PMC ladder interface. Drake Manufacturing provides all software required to run your parts from day one so no customer programming is required. Your operator is only required to enter part specific variables; wheel and dressing roll variables and process information to run parts. Menu and macro software are proprietary to Drake. No source code is provided.

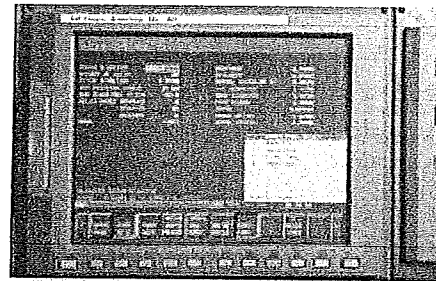
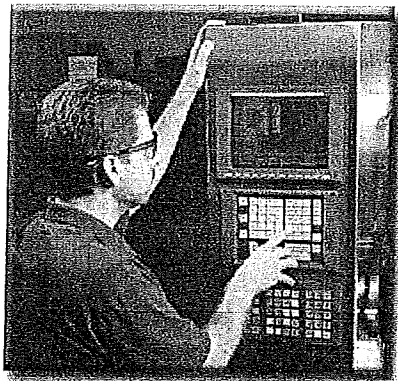


Figure 5: Drake's Simple Menu Entry Screen and HMI

Basic Part Memory. Part and process specific menu entries saved in CNC memory for up to 120 part descriptions, including all process information. Each description is identified by alphanumeric characters. To reload process settings and description for a future setup, the operator simply selects the desired part from directory listing with the push of a button.

External Wheel Spindle. Precision balanced high frequency, 150mm body, motorized spindle with permanent lubrication, refrigeration package, and variable speed drive to hold constant surface speed. Standard wheel flange accommodates a 350mm OD x 25mm W grinding wheel.

Mounts for additional wheel sizes are available upon request. **DANGER! DO NOT EXCEED WHEEL MANUFACTURER'S RATED MAXIMUM SPEED.**

Automatic Wheel Balancer. Wheel-mounted automatic mechanical balancing system installed and interfaced with control system for external spindle. System will balance the wheel down to 0.5 microns peak-to-peak vibration within one minute, and maintain that level through the life of the wheel.

Internal Wheel Spindle. Precision balanced high frequency, 120mm body, motorized spindle with lubrication system, refrigeration package, and variable speed drive to hold constant surface speed. Drake will provide appropriate grinding quill for any one part. Maximum internal grind depth decreases with increasing helix angle.

Wheel Spindle Drive. Control Techniques UniDrive, variable frequency spindle drive supplied and configured for constant and continuously variable wheel peripheral speed operation over wheel size range. Spindle power connector has ID pin to alert control and drive that internal or external spindle is attached.

Diamond Roll Truing. Electric, temperature controlled, motorized rotary diamond dressing unit mounted on worktable behind head stock. Mounting of dresser on same thermal mass and in close physical proximity to work piece minimizes effects of system temperature variations on work piece geometry and dimensions. Wheel forms generated by simultaneous CNC contouring on X- and Z-axes or by plunging with a form roll. One appropriate diamond contouring roll included with order.

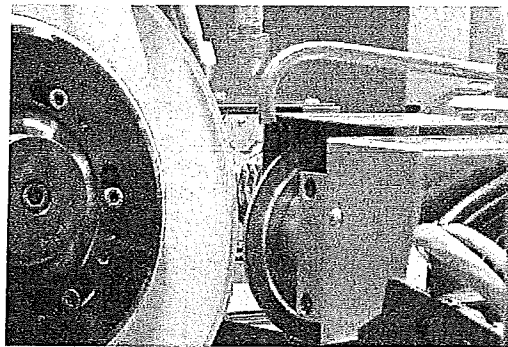


Figure 6: Diamond Roll Contour Dresser

MACHINE UTILITIES, AUXILIARIES, AND DOCUMENTATION

Documentation. One English language Operator Manual, Parts and Components Manual, and Control Configuration and Schematics Manual provided. Fanuc documents provided on CD media.

Electrical System. Complete three-phase, 50- or 60-cycle electrical system in watertight enclosure designed to accommodate customer's incoming supply at 200 to 600 volts. System includes low voltage control circuits and isolation transformer. All work in full compliance with ISO requirements. Customer to provide a dedicated earth ground for noise suppression.

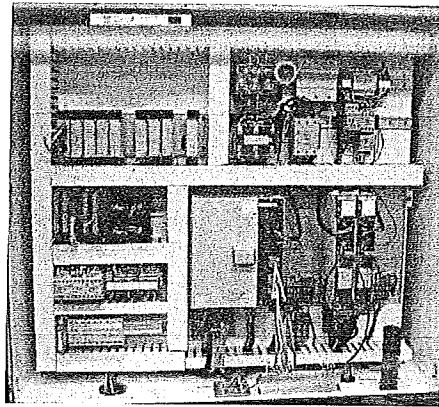


Figure 7: Typical Electric Panel

Pneumatic System. Complete control system to ISO standards for connection to customer shop air at 5 bar (75 psi) minimum. Air used to actuate coolant valves, tailstock center, and to purge linear scales and other components as required.

Coolant Distribution. Machine plumbed with coolant feed lines with control valves and solenoid shut-off valves ready for single point connection to customer's coolant system. Coolant plumbed to grind, dress, and bed wash areas. Optional coolant handling systems available as noted in the pricing schedule.

Painting. Individual components painted using two-part paint over suitable primer. Drake will paint customer's preferred color or provide selection charts as requested.

Guarding. Stainless steel work area enclosure guarding installed to provide for operator safety and coolant containment.

MACHINE RUNOFF, INSTALLATION AND TRAINING

Runoff. Drake will demonstrate the machine's operation on our floor for written acceptance by authorized customer personnel prior to shipment. Runoff criteria are to be agreed upon at time of order. All tooling supplied with base machine or purchased separately will be tested prior to shipment and used for runoff. Customer to supply adequate quantity of part blanks meeting specifications for debug and runoff. Drake can provide a temporary coolant pump/reservoir system for runoff at our plant if optional unit not purchased.

Installation & Start-up. Drake service technicians will install and start up machine at customer's overseas or domestic plant after delivery and placement by customer.

Training. Training is available at no cost at Drake during run-off. We strongly recommend that two operators come to Drake for one full week of training. Training includes process development, part feature definition, controls operation, and preventive maintenance for the complete machine. Additional operator and maintenance personnel training available at customer's plant for additional charge - see pricing schedule.

GS:TE/TI SPECIFICATIONS

Description	350	650
Internal Grinding Applications:		
Thread Grinding Length (Internal)	250 mm	250 mm
Maximum Part Length (Internal)	250 mm	250 mm
Max Thread Diameter (Internal) ¹	300 mm	550 mm
Max Workpiece Diameter (Internal)	350 mm	650 mm
Lead Angle ²	±10°	±15°
Wheel Spindle Power	18 kW	
Spindle Speeds (vc is constant)	30,000 RPM, 45,000 RPM, or 60,000 RPM	
Standard Grinding Wheel Range:		
Types	AlOx ₂ , SG Ceramic, CBN	
Outside Diameter	30 to 100 mm	
Width	6 to 25 mm	
Bore	Assorted	
External Grinding Applications:		
Thread Grinding Length (External)	750 mm	750 mm
Maximum Part Length (External)	750 mm	750 mm
Max Thread Diameter (External)	350 mm	550 mm
Max Workpiece Diameter (External)	350 mm	650 mm
Lead Angle	±35°	
Wheel Spindle Power	12 kW	
Spindle Speeds (vc is constant)	8,000 RPM	
Standard Grinding Wheel Range:		
Types	AlOx ₂ , SG Ceramic, CBN	
Outside Diameter	350 mm	
Width	25 mm	
Bore	160 mm	
Thread Information:		
Threads Forms	60°, 55°, API Acme, Trapezoidal, Buttress, Gothic Arch, Radius, ISO, DIN, Whitworth, Others.	
Wheel Dressing Method	Diamond contour or form roll, single or multi-rib	
Max Thread Form Width x Height	25 mm x 18 mm	
Thread Leads	0-999 mm	
Thread Starts	1-99	
Lead Error in 25mm	≤1.5µm	
Lead Error in Total Length (750 mm)	≤5µm	
Effective Diameter Error	≤4µm	
Typical Surface Roughness	≤Ra0.4µm	
Half Angle Error	≤8'	

¹ Lead angles obtainable are dependent on tooling, part, wheel and quill diameter, and other fixture interference issues

² Maximum thread diameter depends on part outside diameter and wall thickness.

Diamond Dressing Roll Dimensions:	
Diameter	114 to 125 mm
Width	Up to 32 mm
Bore	25.4 mm or specify
Rotary Work Axis:	
Work Head Speed	Up to 300 rpm continuous
Work Head Spindle Nose	A2-8
Drive Method	Fanuc servo motor (high accuracy torque motor work head available)
Speed Reduction	Double enveloping 30:1 gear set
Index Accuracy	≤ 6 arc minutes (accuracy to ≤10 arc seconds available with high accuracy workhead)
Axial Motion of Spindle	≤ 0.001 mm
Radial TIR of Spindle	≤ 0.002 mm
Linear Axes:	
Rapid Return Speed	Up to 10 m/min
Way System	Recirculating roller cars & rails
Drive Method	Fanuc Linear Motors
Encoder Type	Heidenhain glass scale
Encoder Resolution	0.05 μm
Position Accuracy in Travel	≤ 0.005 mm
Minimum Command Move	≤ 0.5 μm
Machine Base:	
Filling	Quartz filled polymer
Electric Cabinet	Attached
Coolant Drain Height	0.5 m above floor
Weight (approximate)	12,000 kg 13,000kg
Dimensions	3m W x 2.6m D 1.8m high
Color	RAL 9002 "Grey White" or specify
Guards	Full enclosure stainless steel
Electrics and CNC Control:	
Number of Interpolating CNC Axes	4
CNC Minimum Resolution	0.1 μm
Brand and Model	Fanuc 0iMx or 30iMx
Servos and Drives	Fanuc
Total Electrical Requirements	10 kVA (up to 32 kVA)
Voltage	200-600 V
Isolation Transformer	Provided
Guards	Stainless Steel
Minimum Coolant Requirements:	
Grind	30 lpm @ 7 bar
Bed Wash	30 lpm @ 1-2 bar
Total Flow	60 lpm (15 gpm)

DRAKE MANUFACTURING GS:TE/TI MACHINE PRICING (USD)

Model GS:TE Thread Grinder (350mm Part Diameter)	\$575,000
Model GS:TE Thread Grinder (650mm Part Diameter)	\$665,000 ✓

Complete turnkey GS:TE four-axis CNC machine as described above, fully programmed and delivered with a grinding process optimized to run customer's parts. Base machine price includes CNC rotary diamond contour dresser and contouring diamond roll ready to condition and dress Aluminum Oxide and Ceramic abrasive wheels. Machine is fully guarded for operator safety and for containment of coolant spray.

GS:TE/TI - Internal Grinding Option (350mm Part Diameter)	\$192,400
GS:TE/TI - Internal Grinding Option (650mm Part Diameter)	\$240,000 ✓

Add internal grinding capability (per specification table above) to basic external thread grinding machine.

Statistical Machine Qualification ("MQ") at Drake Manufacturing (MQ1)	Included
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Install, Startup, Training, and MQ2 at Customer Site

NAFTA	\$24,000 ✓
EU	\$44,300
Asia/India	\$50,300

OPTIONAL EQUIPMENT PRICING

1M Grind Length	\$35,000
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Increase grind length of basic machine to 1,000mm with 1,100mm between centers.

High Accuracy Work Head	\$40,000
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C-axis work head fitted with high precision bearings and driven by a Fanuc torque motor equipped with a Heidenhain 8-million count encoder for positioning accuracy better than 10 arc seconds.

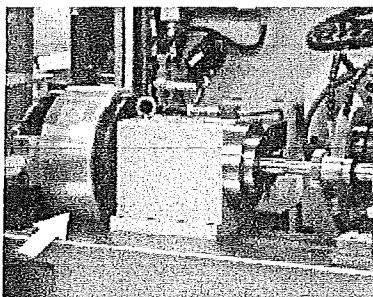


Figure 8: High Accuracy Work Head

Smart Form™ \$32,000 ✓

Drake Smart Form™ software and hardware package corrects wheel forms for helical interference on higher helix parts and for off helix grinding. Also provides a means to upload forms from CAD files in .dxf format directly into the CNC using removable media or network connections. Allows grinding of special forms and provides wash-out correction when grinding at high lead angles.

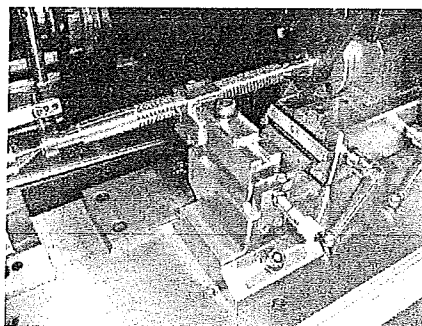


Figure 9: GS:TE Manual Steady Back Rest

Steady Rest \$9,500

Work piece steady backup rest configured to mount on upper table way. Design provides for manual operation, horizontal adjustment and changeable inserts to accommodate different part diameters. Typically, a steady rest is required if part length is greater than 10 diameters.

Centrifuge Coolant Filtration & Chilling System \$49,800

Drake fabricated coolant filtration system with single centrifuge, magnetic separator and 24,000 Btu chiller installed and fully integrated with machine controls. Coolant system complete with 100 lpm (30 gpm) pump, feeds and returns, on a 760 liter (200 gallon) settling tank with baffles, removable basket and lid. Tank painted to match machine. Motor starter with overload protection, fuses, wiring and CNC control of pump included. Operator required to empty centrifuge periodically.

Automatic Paper Bed Grinding Coolant System \$79,800 ✓

ERIEZ/Hydroflow automatic suction filtration system with 18,000 BTU chiller fully integrated and tested with the Drake grinder control. System includes one high volume 100 lpm (20 gpm) clean pump at 7 bar (100 psi) with feeds and returns on a 1,700 liter (450 gallon) two-compartment steel tank. Coolant is filtered to 15 micron clarity through disposable paper filter media. System complete with spent media hopper and transfer sump tank and pump to lift coolant from grinder to filter system. Unit equipped for 50hz operation and is CE marked, if needed.

Mist Collector (ESP Type) with Fire Damper..... \$4,500 ✓

Tri-Mist 850 high efficiency electrostatic precipitation smoke and mist collector system configured to eliminate smoke and mist from exhaust air, up to 99% per ASHRAE 52.1 and effective on all metal working fluids. Unit is equipped with fire damper and does not require disposable filters. It is shipped with one extra ESP cartridge and a HEPA filter.

Fire Suppression System (Domestic)..... \$4,500 ✓**Fire Suppression System (International)**..... \$5,500

Self-contained fire suppression system mounted to machine with controls for automatic activation and provisions for emergency manual operation. System adequately sized for machine enclosure volume.

Direct Plated Full Radius Roll..... \$450**Reverse Plated Full Radius Roll**..... \$2,000 ✓

Reverse or Direct Plated Full Radius – 3mm (0.125") radius, 6mm (0.25") wide, 114mm (4.5") O.D. Used to dress typical thread forms with any flank angle from 0° to 90° and any desired root radius. Reverse plated rolls required for close tolerance forms and smoother surface finish requirements.

Direct Plated 60° Roll..... \$450

Direct plated 60° included flank – 3mm (0.25") wide, 114mm (4.5") O.D., and 29.9 ° flank angles. Used to dress standard 60° thread forms. Roll typically has 0.5mm (0.020") corner radii.

Form Roll..... \$2,500 to \$5,000

Single or multi-rib reverse plated diamond form roll with up to 4 or 5 active ribs (up to 25 mm wide) to plunge dress wheel for faster cycle times. Customer to designate thread pitch and form.

Type 1 CVD Diamond Roll..... \$4,800

Square profile CVD diamond roll with corner radii as small as 0.05 mm (0.002") used to dress forms with very small crest radii or where high precision form (≤ 0.010 mm) conformance is required.

External Storage..... \$5,700 ✓

120 part storage in the CNC with the ability to export and backup part information to an external device, such as a PCMCIA card.

Extended Warranty..... 5% of total purchase order

Optional extended parts and labor warranty. This option provides warranty coverage for an additional twelve (12) month period beyond the original contract. Customer to pay reasonable travel and living expenses incurred during the extended warranty period.

EXPORT PRICING

Native Language Operator Manual	\$12,000
Option to provide one lot of three Operator Manuals in one native language.	
CIF Seaport Shipping	\$14,500
Additional charge for CIF shipment to seaport of choice in lieu of FCA Warren, Ohio terms.	
Packing for Overseas Shipment	\$7,700
Only required if terms are FCA; overseas packing is included in CIF shipping charge.	
Additional On-Site Training	
NAFTA	\$16,600
EU	\$17,300
Asia/India	\$24,200
Five days of additional operator and maintenance personnel training with installation at customer's plant. Training includes process development, controls operation, and preventive maintenance for the complete machine. Travel and living expenses included.	
CE Compliance	\$26,575
Provides the additional requirements to meet CE marking to comply with all applicable product safety, health and environmental requirements within the CE marking system. This includes revised wiring standards, risk assessment, CE marked components, operator manual, and controls in native language, and maintaining a technical construction file for 10 years. Priced per machine. Note: subsequent like machines only \$16,500.	

DELIVERY AND INVOICING

- Runoff at Drake in Warren, Ohio is approximately 8 months after receipt of order, subject to prior sale.
- Terms: Net 30 days
 - For non-USA deliveries: 30% down payment at time of order with irrevocable letter of credit for balance, negotiable with forwarder's cargo receipt, drafts payable at sight.
 - For USA deliveries: 30% at order, 60% at preliminary acceptance, and 10% upon final acceptance at customer plant.

This quotation is subject to the attached Drake "Terms and Conditions of Sale".

Thank you for your interest in our products. If you have any questions, please don't hesitate to call.

Drake Manufacturing Services Co., LLC

A handwritten signature in black ink, appearing to read "James L. Vosmik". The signature is fluid and cursive, with a large, stylized "Q" at the end.

James L. Vosmik
President