GENERAL START-UP INSTRUCTIONS

The properties of the product being processed dictate the best start-up procedure. Operational experience will lead to techniques which may deviate to a degree from the generalities stated herein; however, the basic aim being presented is to "apply the load gradually".

The following general notes apply to all applications of VOTATOR heat exchange apparatus:

1. Turn the mutator shaft by hand, whenever possible, before starting drive motor. This precaution is advisable to insure against blade or tube damage which may occur by starting a unit filled with solidified product.

2. Rotation of the mutator shaft must be counterclockwise viewed from the drive end and should be checked at the initial and all subsequent installations.

3. Prolonged running of the mutator shaft without product or alternate fluid flowing in the system should be avoided to minimize blade, tube, and seal wear.

A perusal of the following examples will illustrate the general approach under various circumstances.

CASE I: HEATING - PRODUCT COMPATIBLE WITH WATER

1. Start product pump taking suction from water supply. Divert system discharge to waste container or drain.

2. After system flow is established, start Votator mutator shaft motor.

3. Admit heating medium to VOTATOR cylinder jacket gradually to attain approximate system operating temperature.

4. Switch pump suction to product supply, and adjust to desired processing rate.

5. Divert product to usage point or container after operating conditions have been reached.

CASE II: HEATING - PRODUCT COMPATIBLE WITH OIL OR SOLVENT

Refer to Case I, substituting oil or solvent where reference is made to water. When product can be recirculated without irreversible change or detriment to quality, alter Case I procedure to recycle until system equilibrium is reached, and omit auxiliary start-up fluid from consideration.

CASE III: HEATING - PRODUCT DILUTION PROHIBITIVE

1. With all equipment at a standstill, i.e. pump, VOTATOR drive, etc., prewarm VOTATOR cylinder with heating medium admitted gradually at approximate desired product temperature.

2. Overshoot product operating temperature approximately 10% or more to compensate for admission of cold product.

3. Start product pump at minimum rate and VOTATOR mutator shaft simultaneously.

4. Divert first product emerging until equilibrium is reached. Adjust processing rate and heating medium as desired.

CASE IV: COOLING - WATER OR BRINE

1. Start product pump, recycle through system and return to supply, or divert to waste container if product cannot be recycled.

2. Start VOTATOR mutator shaft after flow is established.

3. Admit coolant to cylinder jacket gradually.

4. Divert product to usage point when system equilibrium is reached.

CASE V: COOLING - AMMONIA OR FREON DIRECT EXPANSION

1. Start product pump, recycle through system, and return to supply, or divert to waste container if product cannot be recycled.

2. Start VOTATOR mutator shaft after flow is established.

3. Line up condensing system valves for operation and start compressor.

4. Adjust back pressure control valve on VOTATOR accumulator approximately 20 psig above normal operating pressure.

5. Open liquid and suction stop valves.

6. Admit liquid refrigerant from accumulator to VOTATOR cylinder jacket.

7. Gradually reduce setting on back pressure control valve to obtain proper product temperature.

8. Divert product to usage point when system equilibrium is reached.

CASE VI: COOLING - SHUTDOWN PROCEDURES

Shutdown procedure is normally the reverse of the start-up procedures, but must be altered when handling products that solidify at normal ambient temperatures. The following approaches are recommended:

a. Air or high pressure gas may be used to blow the equipment free of product after cooling medium has been secured and warm product circulated.

b. Units employing water or brine for cooling may be shut down full of product if alternate jacket connections are made for heating at start-up with steam or hot water.

c. Compatible fluids, i.e., water, oil, or other solvent, may be used as flushing mediums after the coolant has been secured and the warm product circulated.

PROCESS DEVELOPMENT

Operation of the Votator Division laboratory and applications of VOTATOR apparatus in many industries and widely divergent fields of endeavor have provided a wealth of processing information which can be brought to bear on specific problems which arise during development. Our primary efforts have been directed toward satisfactory application of VOTATOR apparatus but often interrelated problems of handling, pumping, control, formulation and operational technique necessitated corollary activities to effect an overall process solution.

As an aid to initial planning we have included, in the appendix, a typical flow diagram, data sheet, and discussion of the particular processing problem for which you have initially acquired VOTATOR apparatus. Similar addenda are available upon request for the entire listing herein, however, we ask that you limit your request to those subjects relating to your immediate programs as both the listing and the addenda are subjected to periodic review and revisions to reflect the latest information available. In this regard, it is our policy to limit the number of addenda to two per unit, recalling previously furnished addenda in like number when additional subjects are requested. Requests may be directed to your local Votator Division representative.

AVAILABLE ADDENDA

- Addenda No. 1 Heating & Cooling
- Addenda No. 2 Mixing and Aerating
- Addenda No. 3 Cooling and Emulsifying
- Addenda No. 4 Crystallizing
- Addenda No. 5 Cooling and Extruding
- Addenda No. 6 Polymerizing

AUXILIARY EQUIPMENT

Far too often insufficient attention is paid to the minor components of a system grouped together under the heading of auxiliaries. Proper operation depends on each component of a system performing its intended task in a consistent and continuous manner. Cyclic or seemingly unexplainable variations can generally be traced to one or more components functioning erratically or improperly applied.

As an aid to selection and utilization of components, we would like to discuss several of the more important items.

Pumping Units: The general classification of the endless varieties of pumps yields two groups: displacement type and impeller type. Of the two groupings, the impeller type, which includes centrifugal and turbine types, is seldom suitable as the viscosity range of the products being handled is usually beyond its capabilities.

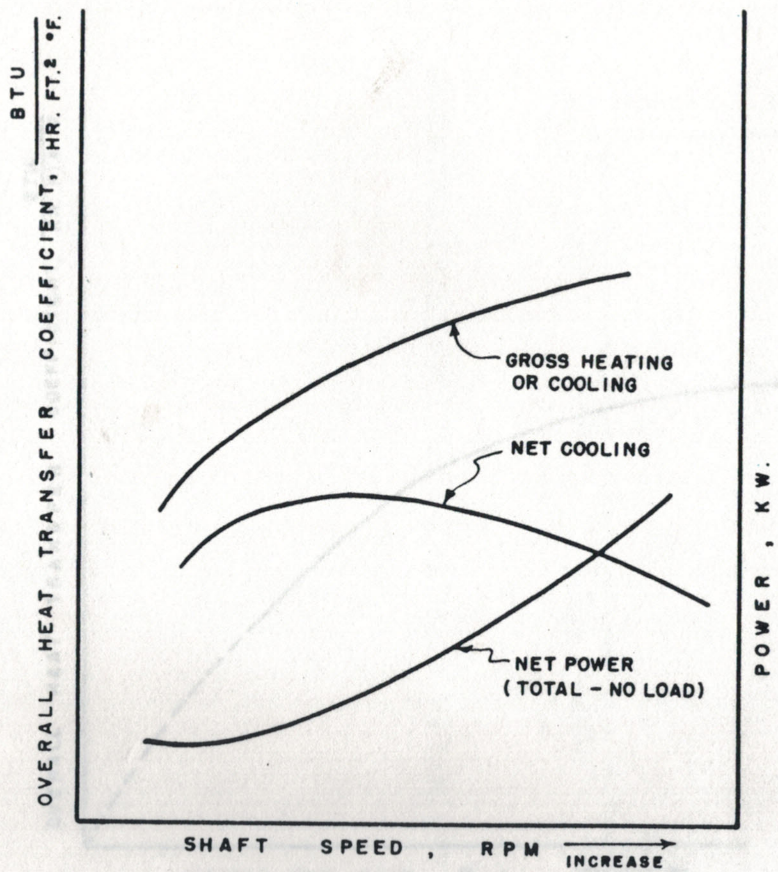
The displacement type pump is the basis of selection in most instances; and at this point some may wonder what happened to the word "positive", since gear, screw, lobe, progressive cavity, and vane type pumps are usually referred to as "positive displacement characteristics". When gear, vane, progressive cavity, internal gear, or lobe type pumps are employed, the system should include adequate provisions for pressure regulation to establish a constant discharge pressure at the pump and, consequently, a constant slippage rate. In this manner, constant delivery can be obtained at a given speed setting.

The position type pump is a true "positive displacement" type and can be relied upon for constant delivery in the face of fluctuating system pressures. Discharge pressures in excess of suction pressures must be maintained, however, to insure proper operation of the pump valves.

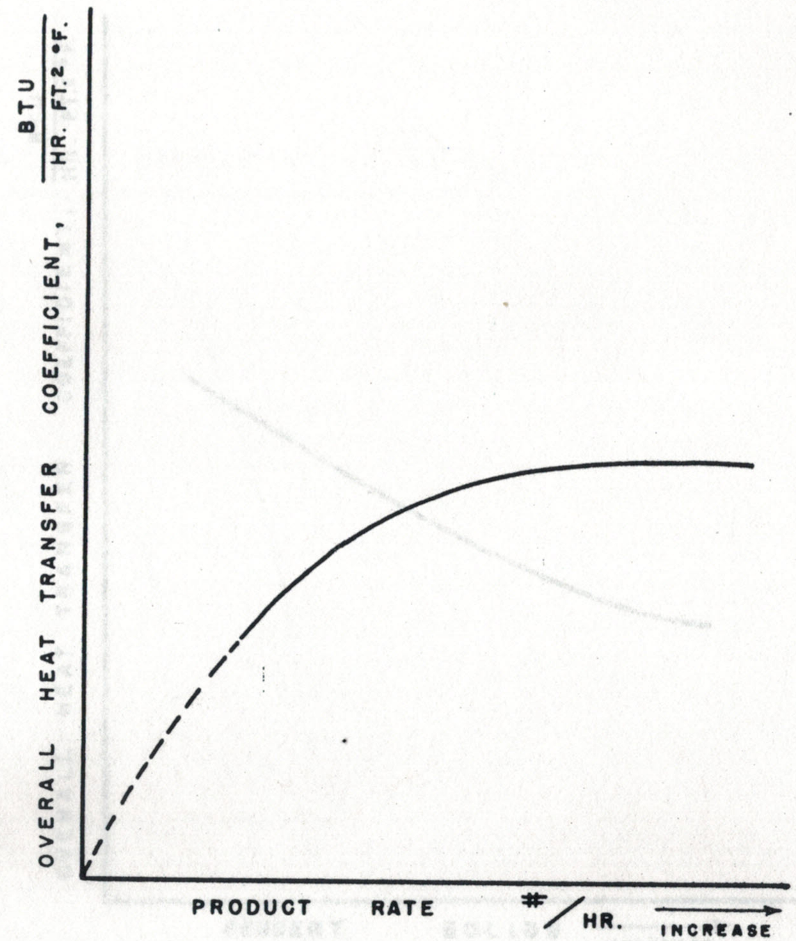
Regardless of pump selection, our recommendations for an experimental unit include a variable drive as the basic premise. Throughput rate is usually one of the most important variables to be studied and should be subject to convenient change and reliable control.

Specialty Valves for regulation of system characteristics are available from Votator Division to meet a wide range of processing problems. Valve types have been developed for aeration or injection control, extrusion, pressure regulation, pressure relief, differential pressure, etc. Use of the several types will be shown in the typical process flow sheets appearing in the addenda.

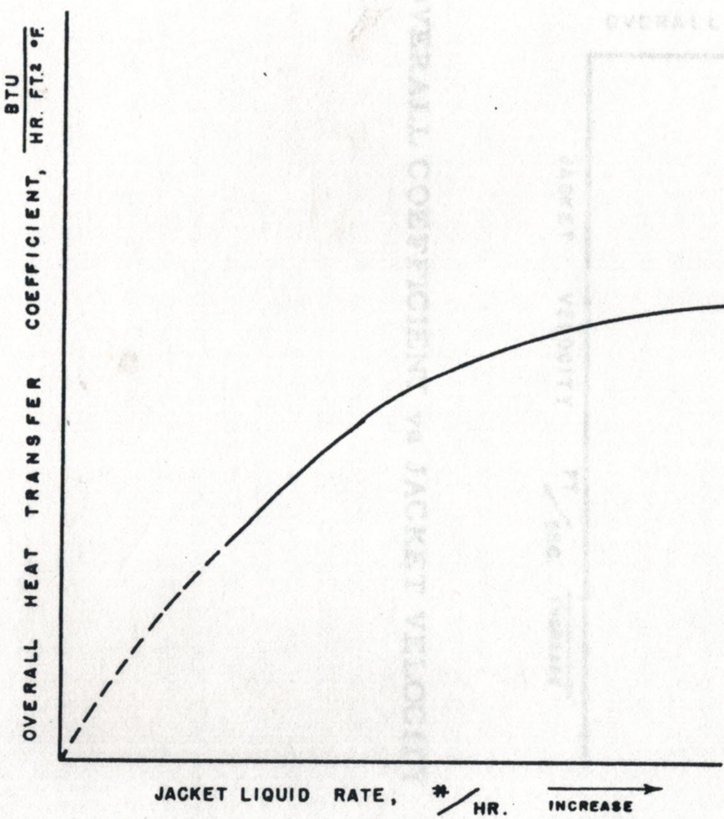
Instrumentation is seldom of a specialized nature in conjunction with VOTATOR experimental apparatus; however, its application should be liberal in a well planned pilot installation. In addition to the normally anticipated gages, thermometers, and controllers, provisions should include a wattmeter, ammeter, or other means for determining the mutator shaft power input when the system is intended for processing viscous products. Data regarding shaft power is particularly important on cooling applications, as the total heat transfer includes power input and must be considered in evaluation of the results.



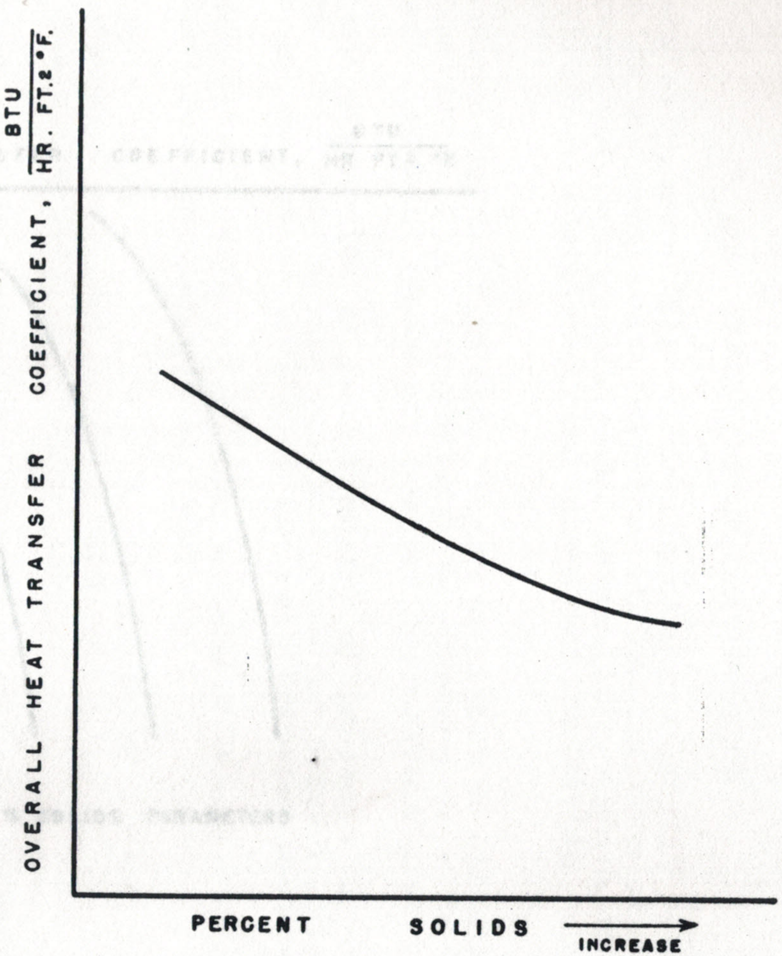
OVERALL COEFFICIENT vs SHAFT SPEED



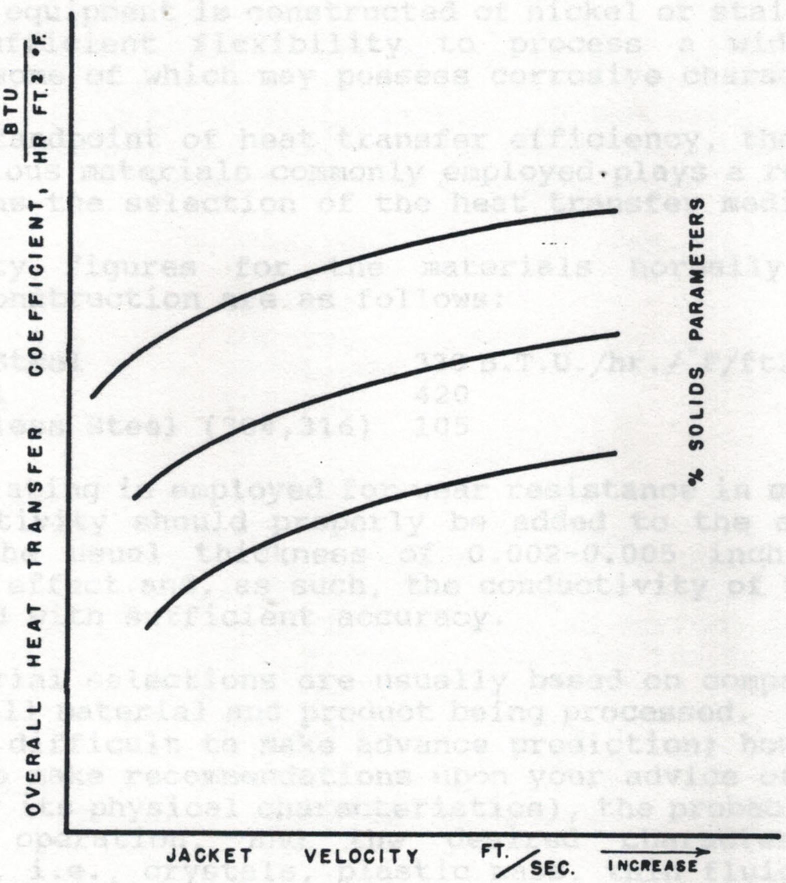
OVERALL COEFFICIENT vs PRODUCT RATE



OVERALL COEFFICIENT vs JACKET LIQUID RATE



OVERALL COEFFICIENT vs PERCENT SOLIDS



OVERALL COEFFICIENT vs JACKET VELOCITY

MATERIALS OF CONSTRUCTION

Commercially, materials of construction are usually selected on the basis of maximum heat transfer efficiency consistent with the necessary corrosion resistance. Other factors which come into play are abrasion resistance and sometimes catalytic effect on the product.

Laboratory equipment is constructed of nickel or stainless steel to provide sufficient flexibility to process a wide variety of products, some of which may possess corrosive characteristics.

From the standpoint of heat transfer efficiency, the conductivity of the various materials commonly employed plays a role equally as important as the selection of the heat transfer medium.

Conductivity figures for the materials normally employed in standard construction are as follows:

Mild Steel	330	B.T.U./hr./˚F/ft2/in. thickness
Nickel	420	"
Stainless Steel (304,316)	105	

Chromium plating is employed for wear resistance in many cases, and its conductivity should properly be added to the above listing; however, the usual thickness of 0.002-0.005 inch will have a negligible effect and, as such, the conductivity of the base metal may be used with sufficient accuracy.

Blade material selections are usually based on compatibility with the tube wall material and product being processed. To this latter end, it is difficult to make advance prediction; however, we will be happy to make recommendations upon your advice of the intended product (or its physical characteristics), the probable temperature range of operation, and the desired characteristics after processing, i.e., crystals, plastic mass, thin fluid, etc.

Please bear in mind that the proper selection of blade type and material often spells the difference between success and failure when processing products having little or no lubricating value or decidedly abrasive characteristics. In the majority of cases these properties do not rule out satisfactory and economical processing; however, they must be recognized in the design conditions when commercial equipment is applied, else excessive maintenance may result. To this end, we strongly recommend that the heat transfer tube and the blades of your laboratory unit be in A-1 condition before embarking on a new program. This enables observation of the wearing qualities of the particular blade and tube combination employed as the work progresses.

VOTATOR laboratory and commercial heat transfer apparatus has been adapted for use with all common heat transfer media and is available upon request for use with special high and low temperature media to customer specifications.

The general purpose unit is suitable for use with brine, water or steam. Standard units are also available for freon, ammonia and dowtherm.

A general understanding of the effect of the various media on the overall heat transfer efficiency is helpful to the interpretation of results. Specific data is lacking on the refrigerants and is, to varying degrees, empirical on the remaining media: however, the general range of jacket side coefficients is as follows:

Steam	1,000-3,000 B.T.U./hr./sq. ft./°f.
Water	500-2,000
Ammonia	200-600
Freon-12	100-500
Brine	150-1,500
Dowtherm A	100-300
Dowtherm E	120-500

The magnitude of the spread of the above values may come as a surprise to some, since the general application of shell and tube equipment usually finds the product side coefficient sufficiently dominant to obscure the effect of the jacket medium. This is also truce in the application of VOTATOR scraped surface exchangers, but to a lesser degree. As an example, consider the following; assume an overall "U" value of 50 when cooling a heavy oil using water at a temperature and velocity such that the jacket side film coefficient is 1200. Use of a brine with a film side coefficient of 600 would decrease the overall "U" value from 50 to approximately 48, or a reduction of about 4 percent, while under the same conditions if the overall "U" value had been 250, the change would decrease the "U" value to approximately 208, or a reduction of nearly 17 percent.

For scale-up purpose, use of the heat transfer medium which will be used commercially is preferable, as it eliminates the need for empirical correlations; however, other considerations often dictate the use of alternate media.

In summary, the important point to remember is that the particular heat transfer medium being used does affect the results; and the higher the "U" value, the greater the effect.

SCALE-UP FACTORS

A detailed treatise of the methods employed in scaling commercial equipment requirements from pilot data is beyond the scope of this booklet and involves many design factors and an intimate knowledge of the equipment characteristics to be effective.

The purpose of the ensuing discussion is to outline the recommended approach to the problem from the standpoint of the user.

An arithmetical scale-up based on heat transfer area is not recommended; however, a factored relationship as shown herein will usually suffice for estimating purposes, as it is weighted to be on the conservative side in most instances.

Assuming comparable materials of construction and conditions of operation, the following approximations are recommended:

4" unit capacity per cylinder	5 times lab rate
6" unit capacity per cylinder	7 times lab rate
10" unit capacity per cylinder	13 times lab rate
24" x 6′ unit capacity per cylinder	30 times lab rate
24" x 10′ unit capacity per cylinder	50 times lab rate

Please bear in mind that heat transfer is not always the criterion for scale-up, in that factors such as agitation, residence time, power requirements, pressure requirements, and the like must all be given consideration in the final selection of the most economical and serviceable commercial equipment.

Upon request, engineers of the Votator Division will be happy to review your data adn effect scale-up recommendations and prepare proposals for the determined equipment. Highly secretive information, such as specific formulation, need not be transmitted; however, indications must be given regarding corrosive or abrasive properties, as well as sufficient physical data to determine handling properties. In this regard, submission of data before cessation of running is highly desirable, as possible factors which may have been overlooked or left unrecorded may still be determined without undue inconvenience.

GENERAL MAINTENANCE

DRIVE: Lubrication instructions are furnished by the drive manufacturer and should be consulted with regard to type of lubricant recommended and frequency of attention. Replacement parts should be obtained direct from the manufacturer, as Votator does not stock these items.

HEAT EXCHANGER ASSEMBLY: The bearing housings contain the only lubrication points on the equipment. This should be lubricated with an NLGI #2 lithium base grease every 100 hours of operation.

The seals, blades, and heat transfer tube should be checked before beginning each testing program and all worn parts reconditioned or replaced. Seal faces must be lapped perfectly smooth and free of pits, crack, etc. to perform satisfactorily. Blades must be properly sharpened and the heat transfer tube honed smooth and free of scores or indentations.

These services may be performed by qualified maintenance personnel or, if you so elect, the parts may be sent prepaid to Votator Division for inspection and reconditioning and/or replacement. Normal handling time involved is approximately 10-30 days, depending on the nature and extent of the work required. Inspection service is offered without charge; however, nominal charges are made for reconditioning and replacement parts.

SHIPMENT SHOULD BE ADDRESSED TO:

CHERRY-BURRELL PROCESS EQUIPMENT
10300 BUNSEN WAY
JEFFERSONTOWN, KENTUCKY 40299

Identifying markings should include your order number assigned to cover the transaction. To prevent delays, previous notification via formal order to other authorizing correspondence should be forwarded to:

CHERRY-BURRELL PROCESS EQUIPMENT
P.O. BOX 35600
LOUISVILLE, KENTUCKY 40232
ATTN: PARTS DEPARTMENT

At the time of initial installation and start-up, a Votator Field Service representative will visit your plant to assist and instruct your personnel in the proper operation and maintenance of the equipment. This service may be included in the original transaction if specified on the sales order.