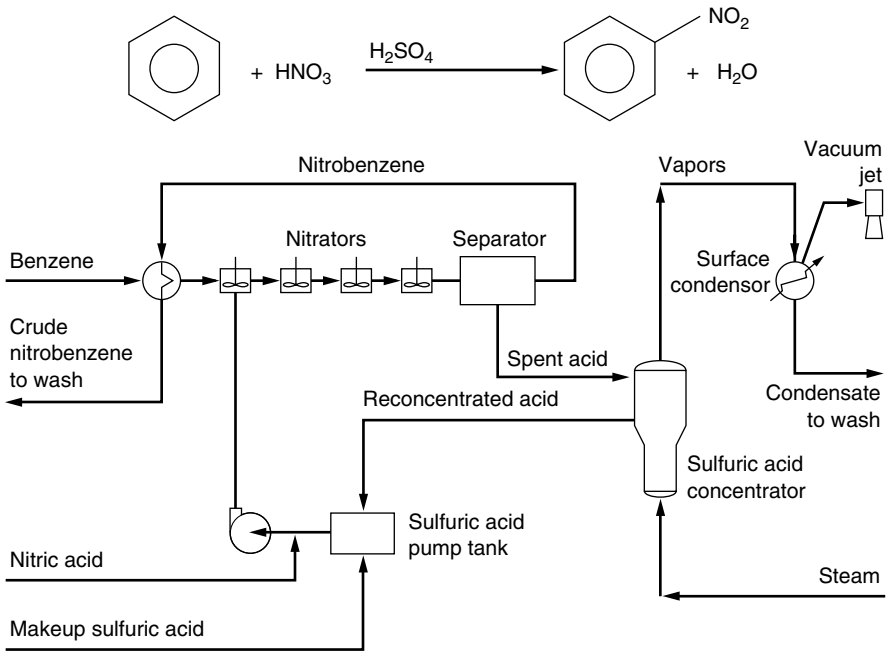
R1.3 Liquid-Phase Industrial Process Flowsheet

A battery of four CSTRs similar to those in Figure 1-10 are shown in the plant flowsheet (Figure RE1-3.1) for the commercial production of nitrobenzene. In 1995, 1.65 billion pounds of nitrobenzene were produced.



Note: Heat Exchange between Benzene feed and Nitrobenzene product

Figure RE1-3.1 Flowsheet for the production of nitrobenzene. [Adapted from *Process Technology and Flowsheet*, Vol. II, reprints from *Chemical Engineering* (New York: McGraw-Hill, 1983), p. 125.]

In 1980 the operating requirements (per ton of nitrobenzene) were as follows (utilities and feedstock requirements have been minimized by recycling sulfuric acid):

Raw materials	
Benzene	0.64 ton
Nitric acid (100%)	0.515 ton
Sulfuric acid (100%)	0.0033 ton
Caustic soda	0.004 ton
Utilities	
Cooling water	14,200 gal
Steam	800 lb
Electricity	20 kWh
Compressed air	180 Scf/m

The feed consists of 3 to 7% HNO_3, 59 to 67% H_2SO_4, and 28 to 37% water. Sulfuric acid is necessary to adsorb the water and energy generated by the heat of reaction. The plant, which produces 15,000 lb nitrobenzene/h, requires one or two operators per shift together with a plant supervisor and part-time foreman. This exothermic reaction is carried out essentially adiabatically, so that the temperature of the feed stream rises from 90°C to 135°C at the exit. One observes that the nitrobenzene stream from the separator is used to heat the benzene feed. However, care must be taken so that the temperature never exceeds 190°C, where secondary reactions could result in an explosion. One of the safety precautions is the installation of relief valves that will rupture before the temperature approaches 190°C, thereby allowing a boil-off of water and benzene, which would drop the reactor temperature.