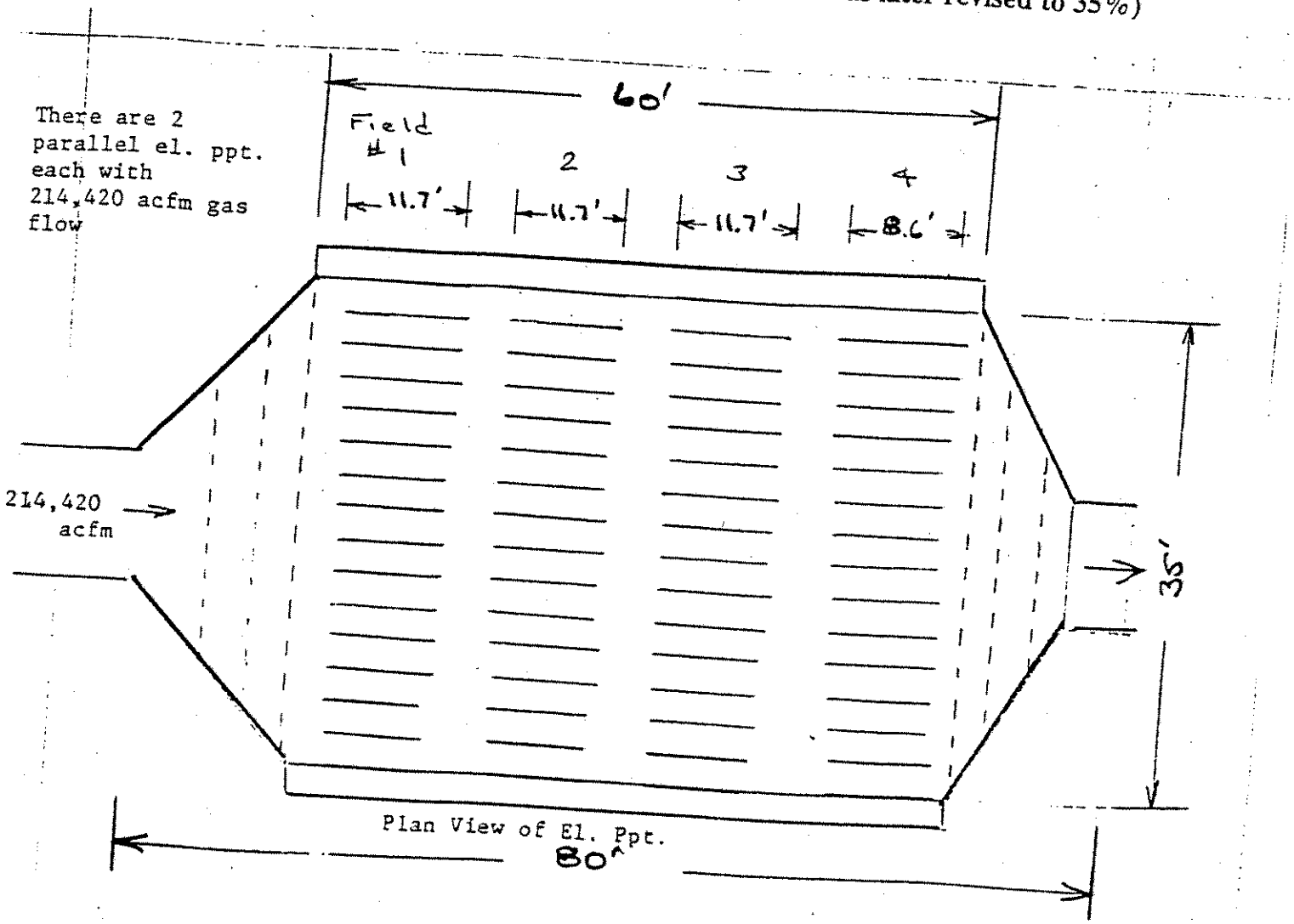
Example E-1 Electrostatic Precipitator on 800 Ton Kraft Pulp/day Mill, Tacoma

Given: Gas flow of 428,840 acfm @ 400°F & 30% water vapor (29.92"Hg Pressure)
Particle Conc. at inlet to el. ppt = 3.5 grains/acf
Electrostatic precipitator features
4 electric fields in direction of gas flow. 3 fields 11.67' and 1 field 8.58' long
total el. ppt. plate length in direction of gas flow = 43.6', plate height=25'
gas flows through 2 parallel sections, each with 214,420 acfm
each section has 40 gas lanes, 10" plate to plate spacing
electric fields powered by 55 kilovolt transformer-rectifier sets (2000 milliamp)
333,000 scf (dry) emitted per ton of air dried pulp
inside diameter of stack at exit to atmosphere = 12 ft = 3.6576 meters
plume opacity Kρ = 1.5 grams particles/m^2 area

Find:
1. SCA = specific collection plate area = A/Q (ft^2 plate area/1000 acfm gas flow)
2. Particulate collection efficiency of el. ppt.
3. Particle mass concentration at el. ppt. outlet (grains/acf and grains/scf)
4. Gas velocity between plates
5. Aspect ratio = plate length / plate height
6. Compare particle emissions with Wash. State Emission Standards
   a. Maximum particle emission of 4 lbs particles/ton air dried pulp
   b. maximum plume opacity of 20% (which was later revised to 35%)



Electrostatic Precipitator on 800 Ton Kraft Pulp/Day Mill, Tacoma

$grain := \frac{lb}{7000}$

Given

Gas flow of 428,840 acfm @ 400°F & 30% water vapor, 1 atm pressure

Particle conc at inlet to electrostatic precipitator = 3.5 grains/actual ft³

Electrostatic features

w = particle migration velocity = 0.2 ft/sec (Table 8.3 pp 281 Noll book)

4 electric fields in direction of gas flow. 3 field 11.67' & 1 field 8.58' long

total el ppt plate length in direction of gas flow = 43.59'

collection plate height = 25'

gas flows through 2 parallel sections, each section with 214,420 acfm

each section has 40 lanes, 10" plate to plate spacing

electric fields powered by 55 kilovolt transformer rectifier (2,000 milliamps)

333,000 scf (dry) gas emitted per ton of air dried pulp made

Inside diameter of stack at exit to atmosphere = 12 ft = 3.6576 meters

plume opacity Kρ = 1.5 grams particles/m² area

$Tstack := 860 \cdot R$

$Tstd := 528 \cdot R$

$Pstack := 1 \cdot atm$

$Pstd := 1atm$

$ftdry := ft$

$ftwet := ft$

$plateheight := 25 \cdot ft$

$numberlanes := 40$

Find

a) SCA = Specific collection plate area = A/Q = (ft² plate surface area)/(1000 acfm gas flow)

b) Particle collection efficiency of electrostatic precipitator = η

c) Particle mass concentration at electrostatic precipitator outlet (grains/acf and grains/scf)

d) Gas velocity between plates

e) Aspect ratio = plate length/plate height

$platelength := 3 \cdot 11.67 \cdot ft + 8.58 \cdot ft$ $\quad platelength = 43.59\,ft$

$CollectionPlateArea := (numberlanes)(2) \cdot (plateheight) \cdot (platelength)$

$CollectionPlateArea = 87180\,ft^2$

$SCA := \frac{CollectionPlateArea}{214420 \cdot ft^3 \cdot min^{-1}}$ $\quad SCA = 406.585 \frac{ft^2}{1000 \cdot ft^3 \cdot min^{-1}}$

a) SCA = 406.585 ft²/1000acfm

$GasFlowRate := 214420 \cdot ft^3 \cdot min^{-1}$

$Migrationvelocity := 0.2 \cdot ft \cdot sec^{-1}$

$\eta := 1 - \exp\left(\frac{-CollectionPlateArea \cdot Migrationvelocity}{GasFlowRate}\right)$ $\quad \eta = 0.9924$

b) Collection efficiency = 99.24%

$InletParticleConc := 3.5 \cdot grain \cdot ft^{-3}$

$OutletParticleConc := (1 - \eta) \cdot (InletParticleConc)$ $\quad OutletParticleConc = 0.0266156\,grain \cdot ft^{-3}$

$Cstd := OutletParticleConc \cdot \left(\frac{Tstack}{Tstd}\right) \cdot \left(\frac{Pstd}{Pstack}\right) \cdot \left(\frac{1 \cdot ftwet^3}{0.7 \cdot ftdry^3}\right)$ $\quad Cstd = 0.06193 \frac{grain}{ftdry^3}$

$Width := 40 \cdot (10 \cdot in)$

$Width = 33.333\,ft$

c) Outlet Particle Mass Conc. = 0.0266 grain/acf = 0.0619 grain/dscf

$GasVelocity := \frac{GasFlowRate}{plateheight \cdot Width}$ $\quad GasVelocity = 4.288\,ft \cdot sec^{-1}$

d) Gas Velocity = 4.288 ft/sec

$GasVelocity = 257.304\,ft \cdot min^{-1}$

$AspectRatio := \frac{platelength}{plateheight}$ $\quad AspectRatio = 1.744$

e) Aspect Ratio = 1.74