

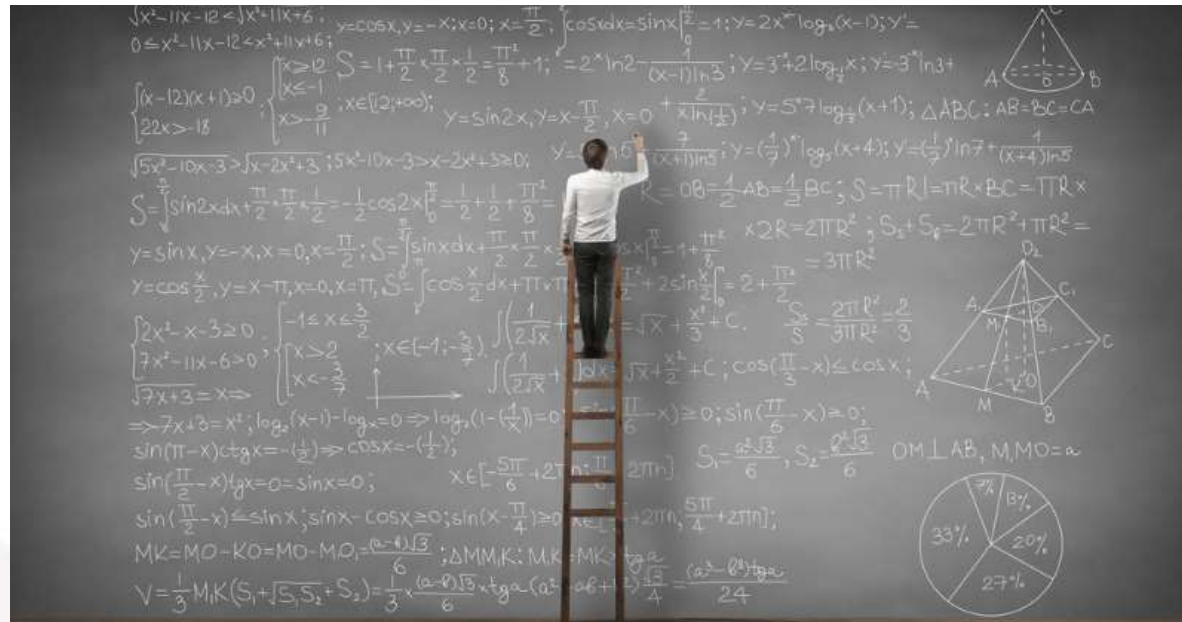
Part 3: Operating a Blending Facility

Session 3.3 Calculating ingredients in a blend formula

Methods to calculate ingredients

Calculate how much of each raw material is required to satisfy the recommendation

- Use a fertilizer blend calculation software
- Calculate it manually



Fertilizer blend calculation software

Advantages:

- Avoid human errors
- Often quicker

Disadvantages:

- Costs



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Manual Calculations

Knowledge needed:

- The interpretation of the formula

For example: NPK 10-10-10 contains 10% Nitrogen (N), 10% Phosphate (P_2O_5), and 10% Potash (K_2O)

- The most common sources of blending ingredients (discussed in session 2.4 of the Blending Guide)

For example: The most common K source is KCl, muriate of potash (MOP), or sulfate of potash (SOP)

- The nutrient content for the raw materials (session 2.4)

For example: Urea contains 46% Nitrogen



Calculating Ingredients



When calculating a blend formula manually, you need to take the following steps, irrespective the type of formula:

- 1. List the nutrients you need to make your blend.**
- 2. Choose the blending ingredients for each nutrient.**
- 3. Check for ingredients compatibility.** In case of non-compatibility, change any of the ingredients.



Calculating Ingredients

- 4. Calculate the kilograms of nutrients needed in the blend on a per-ton (1,000 kg) basis.** The calculations will depend on the type of blend you want to produce.
- 5. Check the nutrient content of your selected blending ingredients.** Raw materials often contain more than one nutrient. In addition, raw materials never contain 100% of the raw material that you need but rather a percentage.
- 6. Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg).** The calculations will depend on the type of formulation.

Example formula 1

NPK 20:10:10 blend



NPK 20:10:10 blend

You need to produce a NPK 20:10:10 blend

Step 1: List the nutrients you need to make your blend

- Nitrogen (N)
- Phosphate (P_2O_5) for Phosphorus (P)
- Potash (K_2O) for Potassium (K)



NPK 20:10:10 blend



Step 2: Choose the blending ingredients for each nutrient

Most common sources of

- **N** are urea, ammonium sulfate, and ammonium from diammonium and monoammonium phosphates >> **Urea**
- **P₂O₅** are SSP, TSP, DAP, and MAP; >> **DAP**
- **K₂O** is MOP or KCl (or muriate of potash) >> **MOP/KCl**

NPK 20:10:10 blend



Step 3: Check for ingredients compatibility

- 1. Chemical compatibility:** The stability of a material when blended with another material.
- 2. Critical relative humidity:** The moisture exchanges between the particles and the surrounding air.
- 3. Physical compatibility:** You check the physical properties (characteristics that enable us to differentiate one material from another) of the materials you want to blend.

NPK 20:10:10 blend



Step 5: Check the nutrient content of your selected blending ingredients

Look at the Annex H and find the following nutrient contents:

- Urea for N contains 46% N
- DAP for P_2O_5 contains 18% N and 46% P_2O_5
- MOP/KCl for K_2O contains 60% K_2O and 45% Cl (we can ignore the Cl here because it is not a nutrient in a NPK blend)

NPK 20:10:10 blend

Raw Material	Weight	N	P ₂ O ₅	K ₂ O
	-----kg/ton-----			
MOP (0-0-60)				
DAP (18-46-0)				
Urea (46-0-0)				
Filler (0-0-0)				
Total	1000	200	100	100
Percent		20	10	10

NPK 20:10:10 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the required P_2O_5 first

- We need 100 kg of P_2O_5 for 1 ton of NPK 20:10:10 (see step 4)
- Use the following formula:

$$100 \text{ kg } P_2O_5 \times \frac{100 \text{ kg DAP}}{46 \text{ kg } P_2O_5} = 217.4 \text{ kg DAP}$$

217 kg DAP will give 100 kg P_2O_5

NPK 20:10:10 blend

Raw Material	Weight	N	P ₂ O ₅	K ₂ O
	-----kg/ton-----			
MOP (0-0-60)				
DAP (18-46-0)	217		100	
Urea (46-0-0)				
Filler (0-0-0)				
Total	1000	200	100	100
Percent		20	10	10

NPK 20:10:10 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the required N

Two sources: Urea and DAP. We know:

- We need 217.4 kg of DAP
- DAP contains 18% Nitrogen

$$18\% \text{ N in } 217.4 \text{ kg DAP} = 39.1 \text{ kg N}$$

- So 217.4 kg of DAP will give you 39 kg of N

NPK 20:10:10 blend

Raw Material	Weight	N	P ₂ O ₅	K ₂ O
	-----kg/ton-----			
MOP (0-0-60)				
DAP (18-46-0)	217	39	100	
Urea (46-0-0)				
Filler (0-0-0)				
Total	1000	200	100	100
Percent		20	10	10

NPK 20:10:10 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- 217.4 kg of DAP will give you 39.1 kg of N
- We need 200 kg of N (calculated in step 4)
- This means we need to get 200 kg minus 39.1 kg = 160.9 kg N out of Urea

$$160.9 \text{ kg N} \times \frac{100 \text{ kg urea}}{46 \text{ kg N}} = 349.8 \text{ kg urea}$$

350 kg Urea will give 161 kg N

NPK 20:10:10 blend

Raw Material	Weight	N	P ₂ O ₅	K ₂ O
	-----kg/ton-----			
MOP (0-0-60)				
DAP (18-46-0)	217	39	100	
Urea (46-0-0)	350	161		
Filler (0-0-0)				
Total	1000	200	100	100
Percent		20	10	10

NPK 20:10:10 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the required K

- We need 100 kg of K_2O for 1 ton of NPK 20:10:10 (see step 4)
- Use the following formula:

$$100 \text{ kg } K_2O \times \frac{100 \text{ kg MOP}}{60 \text{ kg } K_2O} = 166.7 \text{ kg MOP}$$

167 kg of MOP will give 100 kg of K_2O

NPK 20:10:10 blend

Raw Material	Weight	N	P ₂ O ₅	K ₂ O
	-----kg/ton-----			
MOP (0-0-60)	167	0	0	100
DAP (18-46-0)	217	39	100	0
Urea (46-0-0)	350	161	0	0
Filler (0-0-0)	266	0	0	0
Total	1000	200	100	100
Percent		20	10	10

Example formula 2

NPK 10:5:5 blend



Exercise

Calculate the quantity of ingredients needed to blend

- NPK 10-5-5

Ingredients to use

- MAP
- Ammonium nitrate
- SOP



NPK 10:5:5 blend

Step 4: Calculate the kilograms of nutrients needed in the blend on a per-ton (1,000 kg) basis

1 ton (or 1,000 kg) of NPK 10-5-5 fertilizer, contains 10% N, 5% P_2O_5 , and 5% K_2O .

For each ingredient this means:

- 10% N of 1,000 kg = 100 kg N
- 5% P_2O_5 of 1,000 kg = 50 kg P_2O_5
- 5% K_2O of 1,000 kg = 50 K_2O



NPK 10:5:5 blend



Step 5: Check the nutrient content of your selected blending ingredients

Look at the Annex H and find the following nutrient contents:

- Ammonium nitrate for N contains 34% N
- MAP for P_2O_5 contains 11% N and 52% P_2O_5
- SOP for K_2O contains 50% K_2O and 18% S (we will ignore the S here because it is not a nutrient in a NPK blend)

NPK 10:5:5 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the required P_2O_5 first

- We need 50 kg of P_2O_5 for 1 ton of NPK 10:5:5 (see step 4)
- Use the following formula:

$$50 \text{ kg } P_2O_5 \times \frac{100 \text{ kg MAP}}{52 \text{ kg } P_2O_5} = 96.1 \text{ kg MAP}$$

96 kg MAP will give 50 kg P_2O_5

NPK 10:5:5 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the required N

Two sources: Ammonium nitrate and MAP. We know:

- We need 96.1 kg of MAP
- MAP contains 11% Nitrogen

$$11\% \text{ N in } 96.1 \text{ kg MAP} = 10.6 \text{ kg N}$$

96 kg of DAP will give you 11 kg of N

NPK 10:5:5 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- 96.1 kg of MAP will give you 10.6 kg of N
- We need 100 kg of N (calculated in step 4)
- This means we need to get 100 kg minus 10.6 kg = 89.4 kg N out of Ammonium nitrate

$$89.4 \text{ kg N} \times \frac{100 \text{ kg Ammonium nitrate}}{34 \text{ kg N}} = 262.9 \text{ kg An}$$

263 kg Ammonium nitrate will give 89 kg N

NPK 10:5:5 blend

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the required K

- We need 50 kg of K_2O for 1 ton of NPK 10:5:5 (see step 4)
- Use the following formula:

$$50 \text{ kg } K_2O \times \frac{100 \text{ kg SOP}}{50 \text{ kg } K_2O} = 100.0 \text{ kg SOP}$$

100 kg SOP will give 50 kg of K_2O

NPK 10:5:5 blend

Raw Material	Weight	N	P ₂ O ₅	K ₂ O
	-----kg/ton-----			
MAP (11-22-0)	96	11	0	50
Ammonium nitrate (34-0-0)	263	89	0	0
SOP (0-0-50)	100	0	0	50
Filler (0-0-0)	541	0	0	0
Total	1000	100	50	50
Percent		20	5	5

Example formula 3

**Multi-nutrient blend
20-10-10+5S+1.5 Zn+1 B**



Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

You need to produce a multi-nutrient 20-10-10 + 5S + 1.5 Zn +1B blend

Step 1: List the nutrients you need to make your blend

- Nitrogen (N)
- Phosphate (P_2O_5) for Phosphorus (P)
- Potash (K_2O) for Potassium (K)
- Sulfur (S)
- Zinc (Zn)
- Boron (B)



Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 2: Choose the blending ingredients for each nutrient

Most common source of

- Urea for N
- DAP for P_2O_5
- MOP/KCl for K_2O
- ammonium sulfate for Sulfur (S)
- zinc sulfate monohydrate for Zinc (Zn)
- granular borax pentahydrate for Boron (B)



Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 3: Check for ingredients compatibility

- 1. Chemical compatibility:** The stability of a material when blended with another material.
- 2. Critical relative humidity:** The moisture exchanges between the particles and the surrounding air.
- 3. Physical compatibility:** You check the physical properties (characteristics that enable us to differentiate one material from another) of the materials you want to blend.

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 4: Calculate the kilograms of nutrients needed in the blend on a per-ton (1,000 kg) basis

1 ton (or 1,000 kg) of NPK 20-10-10 + 5S +1.5 Zn + 1B fertilizer, contains:

- 20% N of 1,000 kg = 200 kg N
- 10% P₂O₅ of 1,000 kg = 100 kg P₂O₅
- 10% K₂O of 1,000 kg = 100 K₂O
- 5% S of 1,000 kg = 50 kg S
- 1.5% Zn of 1,000 kg = 15 kg Zn
- 1% B of 1,000 kg = 10 kg of B

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 5: Check the nutrient content of your selected blending ingredients

Look at the Annex H and find the following nutrient contents:

- Urea for N contains 46% N
- DAP for P_2O_5 contains 18% N and 46% P_2O_5
- MOP/KCl for K_2O contains 60% K_2O and 45% Cl
- ammonium sulfate (AS) for S contains 21% N and 24% S
- zinc sulfate monohydrate ($ZnSO_4 \cdot H_2O$) for Zn contains 17% S and 35% Zn
- granular borax pentahydrate (borax penta.) for B contains 14.5% B

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)							
DAP (18-46-0)							
MOP (0-0-60)							
AS (21-0-0 +24S)							
ZnSO ₄ *H ₂ O (35 Zn, 17 S)							
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Start with Zn requirements supplied by zinc sulfate monohydrate

$$15 \text{ kg Zn} \times \frac{100 \text{ kg ZnSO}_4 * \text{H}_2\text{O}}{35 \text{ kg Zn}} = 42.9 \text{ kg ZnSO}_4 * \text{H}_2\text{O}$$

43 kg zinc sulfate monohydrate will give 15 kg Zn

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)							
DAP (18-46-0)							
MOP (0-0-60)							
AS (21-0-0 +24S)							
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43					15	
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Calculate the quantity of S that will be supplied when using 42.9 kg zinc sulfate monohydrate
- 17% of 42.9 kg zinc sulfate monohydrate = 7.3 kg S

43 kg zinc sulfate monohydrate will give 7 kg S.

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)							
DAP (18-46-0)							
MOP (0-0-60)							
AS (21-0-0 +24S)							
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- The total S required is 50 kg/ton, so the balance of S that must be supplied by the ammonium sulfate (AS) is $(50-7.3) = 42.7$ kg

$$42.7 \text{ kg S} \times \frac{100 \text{ kg AS}}{24 \text{ kg S}} = 178.0 \text{ kg AS}$$

178 kg AS gives 43 kg S

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Ammonium sulfate also contains N. Calculate how much N will be supplied when using 178.0 kg AS.
- 21% N in 178.0 kg AS = 37.3 kg N

178 kg AS gives 43 kg S and 37 kg N

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)							
DAP (18-46-0)							
MOP (0-0-60)							
AS (21-0-0 +24S)	178	37	0	0	43	0	0
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Continue with DAP because that will supply N and P_2O_5 .
- Start with P_2O_5 .
- Remember:
 - We need 100 kg P_2O_5
 - DAP contains 46% P_2O_5 and 18% N

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

$$\frac{100 \text{ kg } P_2O_5}{\text{ton fertilizer}} \times \frac{100 \text{ kg DAP}}{46 \text{ kg } P_2O_5} = \frac{217.4 \text{ kg DAP}}{\text{ton fertilizer}}$$

18% N in 217.4 kg DAP = 39.1 kg N

*We need 217 kg DAP to get 100 kg P_2O_5
217 kg DAP will give 39 kg N*

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)							
DAP (18-46-0)	217	39	100	0	0	0	0
MOP (0-0-60)							
AS (21-0-0 +24S)	178	37	0	0	43	0	0
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Calculate the Urea required
- We already have
 - 37 kg N from AS
 - 39 kg N from DAP
- We need a total of 200 kg N which means we still need $200 - 37 - 39 = 124$ kg N.

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Calculate the Urea required

$$123.6 \text{ kg N} \times \frac{100 \text{ kg urea}}{46 \text{ kg N}} = 268.7 \text{ kg urea}$$

We need 269 kg Urea to provide 124 kg N.

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)	269	124	0	0	0	0	0
DAP (18-46-0)	217	39	100	0	0	0	0
MOP (0-0-60)							
AS (21-0-0 +24S)	178	37	0	0	43	0	0
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Calculate the MOP required

$$100 \text{ kg K}_2\text{O} \times \frac{100 \text{ kg MOP}}{60 \text{ kg K}_2\text{O}} = 166.7 \text{ kg MOP}$$

We need 167 kg MOP to get 100 kg K₂O

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)	269	124	0	0	0	0	0
DAP (18-46-0)	217	39	100	0	0	0	0
MOP (0-0-60)	167	0	0	100	0	0	0
AS (21-0-0 +24S)	178	37	0	0	43	0	0
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)							
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Calculate the required kg of borax pentahydrate

$$10 \text{ kg } B \times \frac{100 \text{ kg borax penta.}}{14.5 \text{ kg } B} = 69.0 \text{ kg borax pentahydrate}$$

We need 69 kg borax pentahydrate to get 10 kg B

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)	269	124	0	0	0	0	0
DAP (18-46-0)	217	39	100	0	0	0	0
MOP (0-0-60)	167	0	0	100	0	0	0
AS (21-0-0 +24S)	178	37	0	0	43	0	0
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)	69	0	0	0	0	0	10
Filler (0-0-0)							
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate how much filler we need.

- 268.7 kg urea
 - 217.4 kg DAP
 - 166.7 kg MOP
 - 178.8 kg AS
 - 42.9 kg Zn sulfate monohydrate
 - 69.0 kg borax pentahydrate)
- = 943.5 kg, so we need $1,000 - 943.5 \text{ kg} = 56.5 \text{ kg}$ filler

Multi-nutrient blend 20-10-10+5S+1.5 Zn+1B

Raw Material	Weight	N	P ₂ O ₅	K ₂ O	S	Zn	B
	-----kg/ton-----						
Urea (46-0-0)	269	124	0	0	0	0	0
DAP (18-46-0)	217	39	100	0	0	0	0
MOP (0-0-60)	167	0	0	100	0	0	0
AS (21-0-0 +24S)	178	37	0	0	43	0	0
ZnSO ₄ *H ₂ O (35 Zn, 17 S)	43	0	0	0	7	15	0
Borax penta. (14.5 B)	69	0	0	0	0	0	10
Filler (0-0-0)	56	0	0	0	0	0	0
Total	1000	200	100	100	50	15	10
Percent		20	10	10	5	1.5	1

Example formula 4

**“Over formulating” a multi-nutrient fertilizer blend
14-18-18+ 5S+ 1B+ 2.5CaO**

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

You need to produce a multi-nutrient NPK 14-18-18 + 5S + 1B + 2.5CaO blend

Step 1: List the nutrients you need to make your blend

- Nitrogen (N)
- Phosphate (P_2O_5) for Phosphorus (P)
- Potash (K_2O) for Potassium (K)
- Sulfur (S)
- Boron (B)
- Calcium oxide (CaO)



Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 2: Choose the blending ingredients for each nutrient

Most common source of

- Urea for N
- DAP for P_2O_5
- MOP/KCl for K_2O
- ammonium sulfate for S
- boric acid for B
- calcitic limestone ($CaCO_3$) as Calcium source

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 3: Check for ingredients compatibility

- 1. Chemical compatibility:** The stability of a material when blended with another material.
- 2. Critical relative humidity:** The moisture exchanges between the particles and the surrounding air.
- 3. Physical compatibility:** You check the physical properties (characteristics that enable us to differentiate one material from another) of the materials you want to blend.

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 4: Calculate the kilograms of nutrients needed in the blend on a per-ton (1,000 kg) basis

1 ton (or 1,000 kg) of NPK 14-18-18+5S+1B+2.5CaO fertilizer, contains:

- 14% N of 1,000 kg = 140 kg N
- 18% P₂O₅ of 1,000 kg = 180 kg P₂O₅
- 18% K₂O of 1,000 kg = 180 K₂O
- 5% S of 1,000 kg = 50 kg S
- 1% B of 1,000 kg = 10 kg of B
- 2.5% CaO of 1,000 kg = 25 kg CaO

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 4: Calculate the kilograms of nutrients needed in the blend on a per-ton (1,000 kg) basis

- **Multiply 2.5CaO by 0.7147** to get 1.8 Ca, because the source of Ca is calcitic limestone which has a nutrient content in Ca
- **Divide 1B by 3.218** to get 0.311 B₂O₃ because the source of B is boric acid which has a nutrient content in B and is not boron in its pure elemental form

The blend formula on the package should be written as

14-18-18+ 5S+ 0.311B+ 1.8CaO

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 5: Check the nutrient content of your selected blending ingredients

Look at the Annex H and find the following nutrient contents:

- Urea for N contains 46% N
- DAP for P_2O_5 contains 18% N and 46% P_2O_5
- MOP/KCl for K_2O contains 60% K_2O and 45% Cl
- ammonium sulfate (AS) for S contains 21% N and 24% S
- boric acid for B contains 17.5% B
- calcitic limestone for CaO contains 40% Ca

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton -----					
Urea (46-0-0)							
AS (21-0-0 +24S)							
DAP (18-46-0)							
MOP (0-0-60)							
Ca (40 Ca)							
Boric acid (17.5 B)							
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the calcitic limestone required

- We need 18 kg Ca and calcitic limestone (CaCO_3) contains 40% Ca.

$$18 \text{ kg Ca} \times \frac{100 \text{ kg CaCO}_3}{40 \text{ kg Ca}} = 45 \text{ kg}$$

This means we need 45 kg calcitic limestone to get 18 kg Ca

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)							
AS (21-0-0 +24S)							
DAP (18-46-0)							
MOP (0-0-60)							
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)							
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the ammonium sulfate required

- We need 50 kg S and ammonium sulfate (AS) contains 24% S.

$$50 \text{ kg S} \times \frac{100 \text{ kg AS}}{24 \text{ kg S}} = 208 \text{ kg AS}$$

This means we need 208 kg ammonium sulfate to get 50 kg S

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

- Ammonium sulfate also contains 21% N
- 21% from 208 kg *ammonium sulfate* = 44 kg N

This means that 208 kg ammonium sulfate also gives 44 kg N.

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)							
AS (21-0-0 +24S)	208	44	0	0	50	0	0
DAP (18-46-0)							
MOP (0-0-60)							
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)							
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the DAP required

- DAP contains 18% N and 46% P_2O_5 .

$$180 \text{ kg } P_2O_5 \times \frac{100 \text{ kg DAP}}{46 \text{ kg } P_2O_5} = 391 \text{ kg DAP}$$

- 18% of 391 kg = 70 kg N

This means that 391 kg DAP is needed to get 180 kg P_2O_5 . The 391 kg DAP will also give 70 kg N.

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)							
AS (21-0-0 +24S)	208	44	0	0	50	0	0
DAP (18-46-0)	391	70	180	0	0	0	0
MOP (0-0-60)							
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)							
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the Urea required

- Urea contains 46% N.
- Total requirement is 140 kg N. We already have 44 kg from ammonium sulfate and 70 kg from DAP. The balance that remains is $140 - 44 - 70 = 26$ kg of N.

$$26 \text{ kg N} \times \frac{100 \text{ kg urea}}{46 \text{ kg N}} = 57 \text{ kg Urea}$$

This means that 57 kg Urea is needed to get 26 kg N.

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)	57	26	0	0	0	0	0
AS (21-0-0 +24S)	208	44	0	0	50	0	0
DAP (18-46-0)	391	70	180	0	0	0	0
MOP (0-0-60)							
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)							
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the MOP required

- We need 180 kg K_2O . MOP contains 60% K_2O .

$$180 \text{ kg } K_2O \times \frac{100 \text{ kg MOP}}{60 \text{ kg } K_2O} = 300 \text{ kg MOP}$$

This means that 300 kg MOP is needed to get 180 kg K_2O .

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)	57	26	0	0	0	0	0
AS (21-0-0 +24S)	208	44	0	0	50	0	0
DAP (18-46-0)	391	70	180	0	0	0	0
MOP (0-0-60)	300	0	0	180	0	0	0
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)							
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the boric acid required

- We need 3.1 kg B. Boric acid contains 17.5% B.

$$3.11 \text{ kg B} \times \frac{100 \text{ kg boric acid.}}{17.5 \text{ kg B}} = 17.7 \text{ kg boric acid}$$

This means that 18 kg boric acid is needed to get 3.1 kg B.

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)	57	26	0	0	0	0	0
AS (21-0-0 +24S)	208	44	0	0	50	0	0
DAP (18-46-0)	391	70	180	0	0	0	0
MOP (0-0-60)	300	0	0	180	0	0	0
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)	18	0	0	0	0	0	3.11
Filler (0-0-0)							
Total		140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Step 6: Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg)

Calculate the quantity of filler

- The total ingredients per ton is (57 kg urea + 391 kg DAP + 300 kg MOP + 208 kg AS + 45 kg Ca + 18 kg boric acid)/ton = **1,019 kg**.
- This is what is called “over formulation: it occurs when the total kg of raw materials **exceeds 1,000 kg** in a ton, which means that the blend over formulates.

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B
		-----Kg/ton-----					
Urea (46-0-0)	57	26	0	0	0	0	0
AS (21-0-0 +24S)	208	44	0	0	50	0	0
DAP (18-46-0)	391	70	180	0	0	0	0
MOP (0-0-60)	300	0	0	180	0	0	0
Ca (40 Ca)	45	0	0	0	0	18	0
Boric acid (17.5 B)	18	0	0	0	0	0	3.11
Filler (0-0-0)							
Total	1,019	140	180	180	50	18	3.11
Percent		14	18	18	5	1.8	0.311

Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

- Easiest solution: to adjust all ingredients with the same percentage to keep the equal proportions
- $1000 / 1019 = 0.9813$
- All ingredients need to be reduced with factor 0.9813



Multi-nutrient blend 14-18-18+5S+1B+2.5CaO

Raw materials	Weight	N	P ₂ O ₅	K ₂ O	S	Ca	B	0.9813
		-----Kg/ton-----						
Urea (46-0-0)	57	26	0	0	0	0	0	55.9
AS (21-0-0 +24S)	208	44	0	0	50	0	0	204.1
DAP (18-46-0)	391	70	180	0	0	0	0	283.7
MOP (0-0-60)	300	0	0	180	0	0	0	294.4
Ca (40 Ca)	45	0	0	0	0	18	0	44.2
Boric acid (17.5 B)	18	0	0	0	0	0	3.11	17.7
Filler (0-0-0)	0	0	0	0	0	0	0	0
Total	1,019	140	180	180	50	18	3.11	1,000
Percent		14	18	18	5	1.8	0.311	

Summary

Knowledge needed:

- The interpretation of the formula

For example: NPK 10-10-10 contains 10% Nitrogen (N), 10% Phosphorus (P), and 10% Potassium (K)

- The most common sources of blending ingredients (discussed in session 2.4)

For example: The most common K source is KCl, muriate of potash (MOP), or sulfate of potash (SOP)

- The nutrient content for the raw materials (session 2.4)

For example: Urea contains 46% Nitrogen

Summary

When calculating a blend formula manually, you need to take the following steps, irrespective the type of formula:

- 1. List the nutrients you need** to make your blend.
- 2. Choose the blending ingredients for each nutrient.** When looking at the price of ingredients, you need to take transport costs into consideration.
- 3. Check for ingredients compatibility.** In case of non-compatibility, change any of the ingredients.

Summary

- 4. Calculate the kilograms of nutrients needed in the blend on a per-ton (1,000 kg) basis.** The calculations will depend on the type of blend you want to produce.
- 5. Check the nutrient content of your selected blending ingredients.** Raw ingredients often contain more than one nutrient. In addition, raw materials never contain 100% of the raw material that you need but rather a percentage.
- 6. Calculate for each blending ingredient, how many kg you need for 1 ton (1,000 kg).** The calculations will depend on the type of formulation.

Part 3: Operating a Blending Facility

Session 3.3 Calculating ingredients in a blend formula