I . Non Reeling Method

1. Cocoon classification factor

① Percentage of cocoon shell weight

2. Sample of cocoon

① For fresh cocoons

- Up to 100kg per lot, 2.5kg fresh cocoons are sampled at random for classification.
- Up to 4,000kg per lot, 4.0kg fresh cocoons are sampled at random for classification.

a_1 (g)

② For dry cocoons

- Up to 40kg s per lot, 1.0kg dried cocoons are sampled at random for classification.
- Up to 1,600kg s per lot, 1.6kg dried cocoons are sampled at random for classification.

a_2 (g)

3. Methods and calculation

① Drying of sample cocoons

In case of fresh cocoons

- Sample cocoons are dried at 115℃ for 4 hrs.
- The dried cocoons are conditioned in the conditioning room. (At least one day)
  Conditioning room: approximately 20℃, 65%RH
- After conditioning the dry cocoons are weighed. b_1 (g)

In the case of dry cocoons or improper dried cocoons

- Sample cocoons are dried at 115℃ for 2 hrs.
- The dried cocoons are conditioned in the conditioning room. (At least one day)
  Conditioning room: approximately 20℃, 65%RH
- After conditioning the dry cocoons are weighed. b_2 (g)
- Percentage of cocoon drying is calculated, if necessary.

$(b_1/a_1) \times 100$ or $(b_2/a_2) \times 100$

② Elimination of cocoons

- The process of elimination of cocoons are carried out on a table under natural light by the visual sense of inspectors.
- Double cocoons and perforated cocoons should be eliminated completely, while inner side soiled cocoons, outside soiled cocoons, thin end cocoons, thin shelled cocoons, cocoons

with prints of cocooning frame, malformed cocoons, loose shell cocoons and musty cocoons are eliminated based on the cocoon elimination standard picture.

- The eliminated cocoons are weighed. c (g)

③ Percentage of eliminated cocoon (against dried cocoon) is calculated as follows;

$(c/b_1) \times 100$ or $(c/b_2) \times 100$

④ 200 good cocoons are sampled and weighed. d (g)

⑤ Pupae are taken out from the good cocoons.

- The cocoons shell are cut and the pupae are removed from the cocoon shell. Then, if there are any inner side soiled cocoons, they should be taken out of the samples and the weight of sampled good cocoons should be modified accordingly. d (g)
- The cocoons shell are conditioned in the conditioning room at least for one day.
- After conditioning the cocoons shell are weighed. e (g)

⑥ Percentage of the cocoon shell weight is calculated as follows;

$(e/d) \times 100$

⑦ Calculation of classification factor

- Percentage of cocoon shell weight of the sample cocoon is calculated as follows;

$(e/d)\ (1 - c/b) \times 100$

c/b ; c/b_1 or c/b_2

4. Cocoon classification

- Cocoon grade is calculated based on the percentage of cocoon shell weight as shown in Table 1.

Table 1 Cocoon classification by non reeling method

Cocoon grade	Percentage of cocoon shell weight (%)
10 S	54.00～
9 S	52.00～53.99
8S	50.00 51.99
7 S	48.00～49.99
6 S	46.00～47.99
5 S	44.00～45.99
4 S	42.00～43.99
3 S	40.00～41.99
2 S	38.00～39.99
S	～37.99

Ⅱ. Reeling Method

1. Cocoon classification factor

① Percentage of reelability

② Length of cocoon filament

2. Materials and methods

① 200 fresh or dried cocoons are sampled at random from a cocoon lot.

② The reeling test is carried out in duplicate. (A division, B division)

③ Multi-end reeling machine or semi-automatic reeling machine is used.

3. Sample of cocoon

① For fresh cocoons

- Up to 100kg s per lot, 2.5kg fresh cocoons are sampled at random for classification.
- Up to 4,000kg s per lot, 4.0kg fresh cocoons are sampled at random for classification.

a_1 (g)

② For dry cocoons

- Up to 40kg s per lot, 1.0kg dry cocoons are sampled at random for classification.
- Up to 1,600kg s per lot, 1.6kg dry cocoons are sampled at random for classification.

a_2 (g)

4. Cocoon drying conditions

In the case of fresh cocoons

- The weight of cocoons is measured. a_1 (g)
- Sample cocoons are dried by gradually decreasing the temperature from 115℃ to 60℃ for 5 hrs.
- The dried cocoons are conditioned in the conditioning room to be constant weight.
  Conditioning room: approximately 20℃, 65%RH
- Then the conditioned cocoons are weighed. b_1 (g)

In the case of dry cocoons or improper dried cocoons

- The weight of the dried cocoons or improper dried cocoons is measured. a_2 (g)
- Sample cocoons are dried at 80℃ for 3 hrs.
- The dried cocoons are stored in the conditioning room to be constant weight.
- The conditioned cocoons are weighed. b_2 (g)
- Percentage of cocoon drying is calculated, if necessary.

$(b_1/a_1) \times 100$ or $(b_2/a_2) \times 100$

5. Elimination of cocoons

- The process of elimination of cocoons are carried out on a table under natural light by the visual sense of inspectors.
- Double cocoons and perforated cocoons should be eliminated completely, while inner side soiled cocoons, outside soiled cocoons, thin end cocoons, thin shelled cocoons, cocoons with prints of cocooning frame, malformed cocoons, loose shell cocoons and musty cocoons are eliminated based on the cocoon elimination standard picture.
- The eliminated cocoons are weighed.
- Percentage of eliminated cocoon (%) (against dried cocoon) is calculated as follows;

  $(c/b_1) \times 100$ or $(c/b_2) \times 100$

- 200 good cocoons are sampled and weighed. d (g)

  A division; 200 cocoons, d_1 (g)

  B division; 200 cocoons, d_2 (g)

6. Cocoon cooking conditions

① 200 dried cocoons are cooked by two-pan cooking device.

Table 2 Cocoon cooking conditions by two-pan cooking device (Standard condition)

Operation order of cocoon cooking	Pan	Temp.	Time	Note
① Low temperature soaking	2nd	60℃	1 min.	
② High temperature permeation	1st	90～95℃	1 min.	
③ Low temperature permeation	2nd	60～65℃	1 min.	
④ Cooking	1st	95℃	3－4 min.	
⑤ Adjustment	1st	95→50℃ (gradually)	4－5 min.	by shower

Carrier basin: 40～45℃

Water characteristics: pH ; Standard 7.0 (limit 6.8-7.4)

M-Alkali ; Standard 30 ($CaCo_3$ ppm) (limit 15-60)

Total hardness ; Standard 30 ($CaCo_3$ ppm) (limit 20-70)

② This is a standard cocoon cooking condition and it is necessary to change the cooking conditions depending upon the cocoon characteristics.

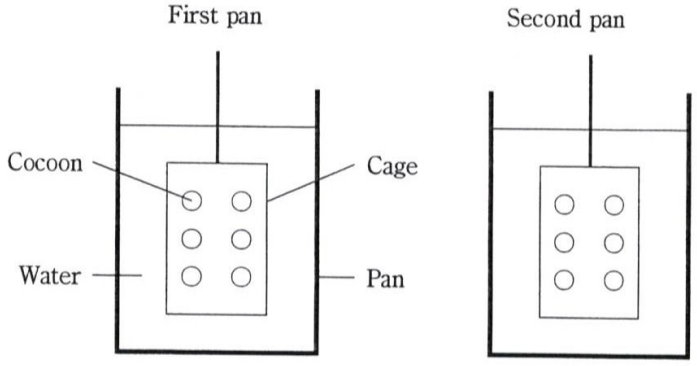

Fig. 1. Cocoon cooking method by using a two-pan cooking device

Table 3 Operation order of cocoon cooking by using two-pan cooking device

First pan	Second pan
	① Low temp. soaking
② High temp. permeation	
	③ Low temp. permeation
④ Cooking	
⑤ Adjustment (by shower)	

①→⑤; Operation order

7. Cocoon reeling conditions

① In order to reel the cooked cocoons, 3 ends multi-end reeling machine or semi-automatic reeling machine equipped with the silk thread length measuring meter and a manual type feeding counter can be used.

② Fixed number of cocoon reeling method ; 9 cocoons are prepared for each end without size detector.

③ Reeling speed is 100 m/min.

④ Reeling temperature is 40℃.

⑤ Manual end feeding method is used.

⑥ Length of croisure is approximately 8㎝.

⑦ Diameter of button hole is approximately 430 microns.

⑧ Water characteristics: pH ; Standard 7. 0 (limit 6. 8-7. 4)
M-Alkali ; Standard 30 ($CaCo_3$ ppm) (limit 15-60)
Total hardness ; Standard 30 ($CaCo_3$ ppm) (limit 20-70)

8. Reeling test

① Brushing and end groping of cooked cocoons;
20～30 cocoons are brushed and end groping is done by hands (the reeler shall brush and grope the cooked cocoons during reeling).

② Reeler shall prepare 9 cocoons per end for 3 ends.
Silk thread is drawn on to the small reel through jetteboute, button, croisure (kennel) system and silk thread length measuring meter.

③ Start of reeling ;
Cocoon feeding to the ends should be performed by hand and if there are any broken ends or dropped cocoons at the beginning of reeling, then the reeler should cast a new cocoon to that end and confirm that each end consists of 9 cocoons. The starting time of the test is the time when all of 9 cocoons begin to reel.

④ During the process of reeling if one cocoon is reeled out completely or if a cocoon drops then the reeler should feed another cocoon to the end and count the total number of feeding cocoons.

⑤ When the reeler is unable to maintain all the 3 ends due to shortage of cooked cocoons then one end silk thread is cut and reeling is continued to reel out all the cocoons and reeling is stopped when the carry over cocoons are 9 in the remaining last end.

⑥ Unreelable cocoons should be picked up and counted and stored separately while reeling.

⑦ After completing the reeling process, the reeler should separate the remaining 9 cocoons into the outer layer cocoons, the middle layer cocoons and the inner layer cocoons.
Outer layer cocoons : In case of outer layer cocoons, Pupae cannot be seen from outside of cocoon by visual sense.
Middle layer cocoon: In case of middle layer cocoons, pupae can be seen from outside of cocoon by visual sense partially.
Inner layer cocoon : In case of inner layer cocoons, Wrinkles on the pupae can be seen from outside of cocoon by visual sense.

⑧ The raw silk is then re−reeled and silk skeins are prepared.

⑨ Calculation of Conditioned silk weight. $(w \times 1.11)$ v (g)

Silk skein shall be placed in the conditioning oven and dried at 140℃ for 40 min, and the skein is weighed. The drying process is continued and the silk skein shall be weighed every 5 minutes till the difference between the last two weights is within 0.1gms. This process is done to calculate the dry weight of the silk skein. (dehydrated weight). w(g)

cf. Actual calculation method of the conditioned silk weight ;

The conditioned weight means, to the dehydrated dry weight of the silk skein add 11% weight as moisture regain because all skeins of raw silk cannot be tested for moisture regain. Then the moisture regain of the sample skeins is calculated as follows.

Moisture regain (M. R.) %

$$\text{M. R. (\%)} = \frac{\text{(Original weight of sample skein)} - \text{(Dehydrated weight)}}{\text{Dehydrated weight}} \times 100$$

The conditioned weight is multiplied with the following coefficient.

$$\text{Coefficient} = \frac{1.11}{1 + \dfrac{\text{M. R. (\%)}}{100}}$$

$$\left(= \frac{\text{Dehydrated weight}}{\text{Original weight of sample skein}} \times 1.11 \right)$$

Conditioned silk weight = Original weight × Coefficient

9. Investigation factors

① 200 dried cocoons weight : d 1 (g), d 2 (g)
② Percentage of eliminated cocoon (%)
③ Total counting number of end feeding time
④ Total length of silk thread
⑤ Number of unreelable new cocoons
⑥ Number of unreelable or carry over outer layer cocoons
⑦ Number of unreelable or carry over middle layer cocoons
⑧ Number of unreelable or carry over inner layer cocoons
⑨ Conditioned silk weight

10. Calculation of classification factors

① Percentage of reelability
- Percentage of reelability (P. R) is calculated as follows;

$$\text{P. R. (\%)} = \frac{\text{(Number of reeled cocoons)}}{\text{(Total number of ends feeding)}} \times 100$$

Where,
- Number of reeled cocoons = (Number of sample cocoons) — (Number of unreelable new cocoons) – (Number of converted carry over cocoons)

· Total number of end feeding time = (Total counting number of end feeding time)
+ (Number of carry over cocoons) − (Number of converted carry over cocoons)
· Number of sample cocoons =200
· Number of carry over cocoons =9
· Number of converted carry over cocoons (for length) =0. 85H +0. 37M+0. 11 L
H : number of unreelable or carry over outer layer cocoons
M : number of unreelable or carry over middle layer cocoons
L : number of unreelable or carry over inner layer cocoons

② Length of cocoon filament
· Length of cocoon filament (L. F.) is calculated as follows;

$$\text{L. F. (m)} = \frac{\text{(Total length of raw silk)} \times \text{(Average number of reeling cocoons per end)}}{\text{(Number of reeled cocoons)}}$$

Where,
· Average number of cocoons per end =9
· Number of reeled cocoons = (Number of sample cocoons) − (Number of unreelable converted cocoons) − (Number of converted carry over cocoons)

11. Cocoon classification

Cocoon grade is calculated by the percentage of reelability and length of cocoon filament as shown in Table 4.

Table 4 Cocoon classification by reeling method

(1) Reelability		(2) Length of cocoon filament	
Mark	Reelability (%)	Mark	Length of cocoon filament (m)
51. 0	85～	43	1401～
50. 5	80～84	42	1301～1400
50. 0	75～79	41	1201～1300
49. 5	70～74	40	1101～1200
49. 0	65～69	39	1001～1100
48. 5	60～64	38	901～1000
48. 0	55～59	37	801～ 900
47. 5	50～54	36	701～ 800
47. 0	45～49	35	601～ 700
46. 5	40～44	34	501～ 600
46. 0	～39	33	～ 500

(3) Final grade

Grade	Result
10G	93.0～
9G	91.5～92.5
8G	90.0～91.0
7G	88.5～89.5
6G	87.0～88.0
5G	85.5～86.5
4G	84.0～85.0
3G	82.5～83.5
2G	81.0～82.0
G	～80.5

Note : The marks obtained in reelability % and the length of cocoon filament are added together and the final grade of the cocoons are calculated accordingly.

12. Optional factors

① Raw silk percentage of cocoon (R. P.)

· Percentage of raw silk against the dried cocoon (R. P.) is calculated as follows;

$$\text{R. P.} = \frac{\text{(Conditioned silk weight)} \times \left(1 - \frac{\text{(Percentage of eliminated cocoons)}}{100}\right)}{\text{(Original dried cocoon weight)} - (\text{(Nccc+Ncuc)} \times \text{(Weight of single cocoon)})} \times 100$$

Nccc = Number of converted carry over cocoons

Ncuc = Number of converted unreelable cocoons

Number of converted carry over cocoons (by weight) =0.80H+0.28M+0.06L

② Size of cocoon filament (S. F) (unit : denier)

· Size of cocoon filament is calculated as follows;

$$\text{S. F. (d)} = \frac{\text{(Conditioned silk weight)} \times 9,000}{\text{(Total length of silk thread)} \times \text{(Average number of cocoons per end)}}$$

13. Calculation examples of cocoon classification factors

1. Percentage of eliminated cocoons (P. E.)

$$\text{P. E. } (\%) = \frac{\text{Weight of eliminated cocoons}}{\text{Weight of dried sampled cocoons for classification } (b_1 \text{ or } b_2)} \times 100$$

For example;

Weight of dry sample cocoons for classification 983. 2g

Eliminated cocoons (dry state) 8. 3g

$$\text{P. E. } (\%) = \frac{8.3}{983.2} \times 100 = 0.84$$

Percentage of eliminated cocoons=0. 8(%)

2. Percentage of reelability (P. R.)

$$\text{P. R. } (\%) = \frac{\text{Number of reeled cocoons}}{\text{Total number of feeding ends}} \times 100$$

Number of reeled cocoons = (Number of sample cocoons) − (Number of unreelable new cocoons) − (Number of converted carry over cocoons)

Total number of feeding ends = (Total counting number of end feeding time) + (Number of carry over cocoons) − (Number of converted carry over cocoons)

Number of converted carry over cocoons (for length) =0. 85H+0. 37M+0. 11L

H : Number of unreelable or carry over outer layer cocoons

M : Number of unreelable or carry over middle layer cocoons

L : Number of unreelable or carry over inner layer cocoons

For example;

Number of sample cocoons = 200

Number of carry over cocoons = 9

Total number of feeding end = 232

Number of unreelable new cocoon = 1

Number of unreelable middle layer cocoons = 3

(This has no relation with the calculation of P. R.)

Number of outer layer cocoons = 2

Number of middle layer cocoons = 4

Number of inner layer cocoons = 3

Number of converted carry over cocoons=0. 85×2+0. 37×4+0. 11×3=3. 51 →4

Number of reeled cocoons=200−1−4=195

Total number of end feeding ends=232+9−4=237

$$\text{P. R. (\%)} = \frac{195}{237} \times 100 = \underline{82} \quad \text{(A division)}$$

If the percentage of reelability of B division is 79% and the average of A and B division is 80. 5 (%), then the percentage of reelability of the sampled lot is 81%.

3. Length of cocoon filament (L. F.)

$$\text{L. F.} = \frac{\text{(Total length of raw silk)} \times \text{(Average number of cocoons per end)}}{\text{(Total number of reeled cocoon)}}$$

Average number of cocoons per end = 9

Total number of reeled cocoons = (Number of sample cocoons) − (Number of converted unreelable cocoons) − (Number of converted carry over cocoons)

For example;

A division;

Number of sample cocoons = 200

Total length of silk thread = 21, 610m

Average number of cocoons per end = 9

Unreelable cocoon

Unreelable new cocoon (P) = 1

Unreelable middle layer cocoons (M) = 3

Number of converted unreelable cocoons (for length) =1. 00P+0. 85H+0. 37M+0. 11L
=1. 0×1+0. 85×0+0. 37×3+0. 11×0
=2. 11 →2

Number of carry over cocoons

Number of outer layer cocoons = 2

Number of middle layer cocoons = 4

Number of inner layer cocoons = 3

Number of converted carry over cocoons (for length) =0. 85H+0. 37M+0. 11L
=0. 85×2+0. 37×4+0. 11×3
=3. 51 →4

Total number of reeled cocoons = 200−2−4 = 194

$$\text{L. F.} = \frac{21,610 \times 9}{194} = 1,002.5 \text{ (m)} \rightarrow \underline{1003 \text{ (m)}}$$

If the length of cocoon filament of B division is 1, 010m and the average of A and B division is 1, 006. 5m, then the length of cocoon filament of the sample lot is 1, 007m.

Grading;

If the reelability % of a lot is 81%, then the points obtained are 50. 5 (from Table 2).
If the length of cocoon filament is 1, 007m, then the points obtained are 39 (from Table 2).
By adding the above two the total is 89. 5, so the grade of the lot is 7G.

4. Raw silk percentage of cocoon (R. P.)

① Raw silk percentage of cocoon (R. P.) against dry cocoon weight

$$\text{R. P.} = \frac{\text{(Conditioned silk weight)} \times \left(1 - \frac{\text{(Percentage of eliminated cocoons)}}{100}\right)}{\text{(Original dried cocoon weight)} - (\text{Nccc} + \text{Ncuc}) \times \text{(Weight of single cocoon)}} \times 100$$

Nccc = Number of converted carry over cocoons
Ncuc = Number of converted unreelable cocoons
Number of converted carry over cocoons (for weight) $= 0.80\text{H} + 0.28\text{M} + 0.06\text{L}$

For example;

Original dry cocoon weight=312. 0g (Total of A and B division)

Conditioned silk weight * A division; 60. 5g
B division; 61. 2g
Total; 121. 7g

Number of sample cocoons A division; 200
B division; 200
Total; 400

Carry over cocoons A division; Outer 2, Middle 4, Inner 3
B division; Outer 4, Middle 2, Inner 4

Number of converted carry over cocoons

A division; $0.80 \times 2 + 0.28 \times 4 + 0.06 \times 3 = 2.90 \rightarrow 3$
B division; $0.80 \times 4 + 0.28 \times 2 + 0.06 \times 4 = 4.00 \rightarrow 4$
Total; 7

Percentage of eliminated cocoons=0. 8%

$$\text{Weight of single cocoon}=\frac{312}{400}=0.78\text{g}$$

$$\text{R. P.}=\frac{121.7}{312.0-7\times0.78}\times\left(1-\frac{0.8}{100}\right)\times100$$

$$=0.397\times0.992\times100$$

$$=39.38\%\qquad\text{(against dry cocoon weight)}$$

② Raw silk percentage of cocoon against the fresh cocoon weight

If the percentage of cocoon drying (b/a ×100) is calculated, then the raw silk percentage of cocoon against fresh cocoon weight is calculated by the following formula;

$$\text{R. P.}=\frac{\text{(Conditioned silk weight*)}\times\text{(Percentage of cocoon drying)}\times\left(1-\frac{\text{(Percentage of eliminated cocoon)}}{100}\right)}{\text{(Original dry cocoon weight)}-\text{(Number of converted carry over cocoons)}\times\text{(Weight of single cocoon)}}\times100$$

For example;

Percentage of cocoon drying; 43%

$$\text{R. P.}=\frac{121.7\times43}{312.0\times7\times0.78}\times\left(1-\frac{0.8}{100}\right)=\underline{16.93\%}\quad\text{(against the fresh cocoon weight)}$$

cf. * Conditioned silk weight

Moisture regain (M. R.) is calculated as follows;

$$\text{M. R. (\%)}=\frac{\text{(Original weight of sample skein)}-\text{(Dehydrated weight)}}{\text{Dehydrated weight}}\times100$$

The conditioned weight is multiplied with the following coefficient.

$$\text{Coefficient}=\frac{1.11}{1+\frac{\text{M. R. (\%)}}{100}}$$

$$=\frac{\text{Dehydrated weight}}{\text{Original weight of sample skein}}\times1.11$$

Conditioned silk weight = Original weight × Coefficient

For example;

A division;

$$\text{M. R.} = \frac{30.6-27.3}{27.3} \times 100 = 12.0\ (\%)$$

$$\text{Coefficient} = \frac{1.11}{1+0.12} = 0.99$$

Conditioned silk weight=61.1 × 0.99= 60.5g

If the original weight of B division is 61.8g,
Conditioned silk weight=61.8× 0.99=61.2g
Then, total conditioned silk weight of A and B division=60.5+61.2=121.7g

5. Cocoon filament size (C. F.)

$$\text{C. F.} = \frac{(\text{Conditioned silk weight}) \times 9,000}{(\text{Total length of raw silk}) \times (\text{Average number of reeling cocoons per end})}$$

For example;
A division;
Total length of silk thread=21, 610m
Conditioned silk weight =60.5g
Average number of cocoons per end =9

$$\text{C. F.} = \frac{60.5 \times 9,000}{21,610 \times 9} = \underline{2.80d}$$

If the cocoon filament size of B division is 2.84d, the average of A and B division is 2.82d.